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THE "LITHOGRAPHIAE WIRCEBRUGENSIS" OF BERINGER.

(With Photographs by the Author.)

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The history of the progress of science in the earlier portions of the Christian Era is the history of the contention between science and theology. The subsequent growth of the scientific method has resulted in the establishment, not only of the validity of much of that which was formerly considered by the church to be sacrilegious falsehood, but also the validity of many of the doctrines upon which the system of Christian ethics is based. And although, during the centuries-long contention, the older systems of formally organized theology have suffered defeat at many points, yet the fabric of Christianity and the *raison d'être* of religion as a vital element in the life of mankind have been the more firmly grounded thereby.

The work which we are to consider, namely, the *Lithographiae Wircebrugensis* of Beringer, had its origin as a result of and in the troublous times of that portion of the theologico-scientific struggle which followed the Reformation. In order to appreciate Beringer and his work, a work which commemorates at once a most colossal farce and a most pitiable tragedy, it is necessary to take a cursory review of the status of science and theology at that period, namely, the latter half of the seventeenth and earlier half of the eighteenth centuries. The evaluations which the church in earlier centuries had set upon the study of the material world and of its various manifestations had not yet ceased to exert a controlling influence. The minds of those who might have turned to an unprejudiced examination of the multitudinous unexplained natural phenomena, with which they were surrounded, were fettered by the traditional attitude of the church, both Protestant and Catholic, an attitude which had been as-

sumed by the early Christian theologians. Their position with regard to geology, zoology, and kindred fields of science had been one not only of indifference, but even of contempt and open antagonism. The common opinion that the material world, being a world of evil, "a fallen world," was doomed after a short existence to inevitable destruction, lent no support to the study of that world which the Creator apparently considered of no value. The scorn which St. Augustine had cast upon the study of astronomy had extended itself to other sciences as well.

However, the attempts to crush out purely secular scientific observation and deduction and to substitute theological scientific methods were not at first wholly successful, even during the youthful periods of the Mother Church's history. All minute reasoning, however, was firmly fettered and unless a scientific fact could be turned to good account in the support of a theological dogma it was dismissed as worthless, and even pernicious, since it tended to lead men into vain speculations which indeed, it was considered, might be a ruse of the Evil One to lure minds into a distrust of the revelations of the Scriptures. It was a reflection of this spirit of interpreting natural phenomena in terms of theological needs which led St. Jerome solemnly to affirm that the fractured and contorted rock layers exposed upon the surface of the earth symbolized the wrath of God against sin. Numerous examples of typical theologico-scientific questions which were discussed among the church fathers of this earlier period can be found in St. Augustine's *De Genesi,* a work put forth at about the beginning of the fifth century in an attempt at once to classify and to delimit that bulk of scientific information and method which might be considered scared and salutary to faith. Some of the questions which it recommends for pious study and meditation are: "Why did not the Creator say to plants as well as to animals, 'Be fruitful and multiply'?" "Why were the heavenly bodies created on the *fourth* day?" The bulk of the scientific knowledge of the world at this time consisted principally of answers to these and a host of similar questions, all having their *raison d'être* in the statements of Scripture or in the dogmas of the church founded thereupon.

But of all the perplexing questions in the rapidly growing fields of zoology and geology, perhaps the one which caused the greatest confusion of theories was the question concerning the origin and significance of fossils. The occurrence of the

forms of bizarre fishes, plants, and other organic forms imbedded within the strata of the sedimentary rocks proved to be too much for the early theologians to explain with any degree of mutual satisfaction. It is in the field of paleontology, then, that we find the greatest number of varying theories, and the general helplessness of the majority of scholars when confronted by this problem can be inferred from the hollow generalities which they put forward in explanation. Thus the presence of fossil forms in the rocks was variously accounted for by "stone-making forces," "formative qualities," a growth from seeds, and the like. Even the much-abused doctrine of spontaneous generation was brought forward to lend its aid.

The influence of the Reformation was at first distinctly unfavorable to the spread of the ideals of scientific progress, for nothing akin to a toleration of latitude in interpreting the Scriptures was to be found in any of the Protestant leaders of the movement. Thus Luther vigorously denounced the idea that the planets revolve about the sun, and many other notions also, which were at variance with the literally interpreted statements of the Biblical text.

So robust was the opposition of the reformist leaders to anything like freedom of interpretation of Scripture, that in Germany the period immediately succeeding the Reformation was characterized by even more intolerance for the scientific view than that which had marked the Reformation itself. Luther's dicta concerning the interpretation of passages of Scripture were held to be little less sacred than the Holy Writ itself, and any deviation from his views was considered not far removed from actual sacrilege. The spark of purely secular scientific thought was not entirely quenched, however, and later, during the seventeenth century, it waxed stronger and more vigorous, bursting into flame here and there, the earnests of a wider conflagration, which, at a later period, was to illumine the field of science and to point the way for such men as Buffon, St. Hilaire, Lyell, Darwin and a host of others.

In France, likewise, the old spirit of theology still retained much of its pristine power, and as late as the middle of the eighteenth century exercised a no mean measure of judicature over matters scientific. Thus it was that when Buffon made a modest attempt to set forth what he considered a body of irrefutable geological statements, the theological faculty of the Sorbonne, incensed at what they were pleased to term a sacri-

ligious attack upon the tenets of The Faith, at once deprived him of his honorable position in the university, forced him to recant, and in the most ignominious manner to print and publish his recantation. A portion of this interesting and humiliating document reads as follows: "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact. I abandon everything in my book respecting the formation of the earth, and generally all which may be contrary to the narrative of Moses."

This brings us down to the time when there was published at Wurzburg a work which among all others of a natural scientific character stands out in prominence as a memorial at once of an almost incredible hoax and of a pitiful story of broken ambition and humbled pride. I refer to the work mentioned above, the *Lithographic Wirceburgensis*. Johann Bartholomaeus Adam Beringer, its author, lived during the first half of the eighteenth century, and at the time of the publication of the work which has made his name known, held the honorable degrees of Doctor of Philosophy and of Medicine, occupied a chair in the University of Wurzburg, and was private physician to the Prince Bishop. He had already distinguished himself by his scholastic activities in the university and was known to be a capable and learned physician and natural philosopher. He had been the author of a medical treatise in 1708[1] and had contributed to the literature of botany some fourteen years later.[2] He had also shown himself to be a no mean paleontologist until his unfortunate venture upon the subject of the figured stones of Wurzburg in 1726. That episode we will now recount.

Beringer had wholly committed himself to the belief that fossils were merely capricious fabrications of God, hidden in the earth for some inscrutable purpose, possibly merely for His own pleasure, possibly as a test for the faith of mankind. His tenure of this position became so strong and so well known at Wurzburg that some of the students of the university, together perhaps with some wags from the town, determined to put his faith in this doctrine to a rigorous trial. They therefore made numerous "fossils" of clay which they buried upon the side of a hill amid thick bushes where they knew the worthy professor was wont to ramble in his search for specimens. In accordance

[1]*Connubium Galenico-Hippocratium*, Wurzburg, 1708.
[2]*Plantarum Exoticarum Perennium Catalogus*, Wurzburg, 1722.

with their hopes, Beringer chanced upon these "fossils" in one of his geological excavating tours, was completely deceived as to their true nature, and overjoyed to discover such evident proofs of the direct agency of God in the creation of these forms, made known the facts of his discovery at the university. The jokers, perceiving with glee the success of their trick now went even farther and buried the most bizarre and monstrous figures which their imaginations could suggest. Not content with this they fashioned inscriptions in Hebrew, Babylonian, Syrian, and Arabic, one of them being the name of God Himself! These they buried near the spot where they had concealed the first. The elation of Beringer on discovering these latter forms was unbounded. He was now convinced of the soundness of his doctrines and made impressive preparations to publish a full account of his discovery and to elaborate learnedly upon its significance, animated by no meaner motive than to vindicate the doctrines of the church regarding matters paleontological and to settle once and for all the vexatious question relative to the origin of fossils. Of the outcome of his researches and of the learned book which he published we shall presently learn.

The book itself, a large quarto, consists of an allegorical frontispiece, a title page devoted mainly to a lengthy exposition of Beringer's position, degrees, and honors, a dedication plate, followed by a nine-page dedication, a preface or *prooemium* of about equal length, fourteen chapters, and twenty-one plates containing the figures. The title page informs us that the work is the *"Lithographiae Wirceburgensis,* illustrated with the marvelous likenesses of 200 figured, or rather insectiform stones" . . . by *"D. Joanne Bartholomaeo Adamo Beringer, Philosophie & Medicinae Doctore* . . . etc." and printed in Wurzburg in 1726. Some contribution was also made by one Georgius Ludovicus Hueber, who is also mentioned on the title page, but the bulk of the work was the result of the anxious and painstaking labors of the worthy and credulous doctor of medicine and philosophy.

The sounding and pompous dedication, nine full quarto pages long, is to D. Christopher Francis, Prince Bishop of Wurzburg, "Most Reverend and Most Emminent Prince and Merciful Lord." It begins with an exposition of the significance of the frontispiece, which is an amazing and pretentious allegorical representation of the profound significance of Beringer's paleon-

tological discoveries. In the center rises a mound composed of the "figured or rather insectiform stones" upon which recline (as significative of their debt to the truth established by the book) the patrons of the various arts, teachers and children. Midway up the mound is the figure of a divine child messenger tracing upon its tablets the inscriptions which it had pleased God to conceal in the earth for Beringer's ultimate discovery. In the fore-

FIG. I. THE FRONTISPIECE.

ground, to the right, stands a table, bearing the following passage from Ovid: "It (the earth) brought forth innumerable forms, some like unto those which had existed before, and some new monsters."[3]

But the most dauntless portion of this allegorical picture is the delineation of the arms of the reigning prince and the triangle of the Holy Trinity (signifying the glory of heaven), both

[3]Ovid, *Metamorphoses*, Bk. I, l. 436.

represented as magnified by the work of Beringer, by being placed on the top of the mound.

After the preface, or *prooemium,* come fourteen chapters containing an account of the finding of the stones, the methods which Beringer used to safeguard himself against making errors in his data, the description of the hill where the digging had been carried on, and so forth. He refutes the view that the figured

FIG. II.

stones might possibly be vestiges of the early pagan occupation of the land (viz., the occupation by the Gauls), and elsewhere affirms it to be his belief that fossils are made by the Creator and hidden in the earth either merely for His own pleasure or possibly as a test for human faith, and that therefore it is not surprising to find the images of bizarre creatures, the counterparts of which never existed as living forms. Thus it was that Beringer was not a whit perturbed when he unearthed such forms, indeed their presence increased his assurance in the in-

tegrity of his discoveries, stimulated him to greater endeavors, and strengthened his faith in the inscrutability of Providence.

We can picture to ourselves the pious fervor of the old scholar as he labored over his great work, his mind dwelling fondly upon the acclamation with which it would be greeted at its publication, of those to whom the preservation of the dogmas of the church against a growing sacrilegious science was ever a foremost concern. Not only would his proofs of God's direct

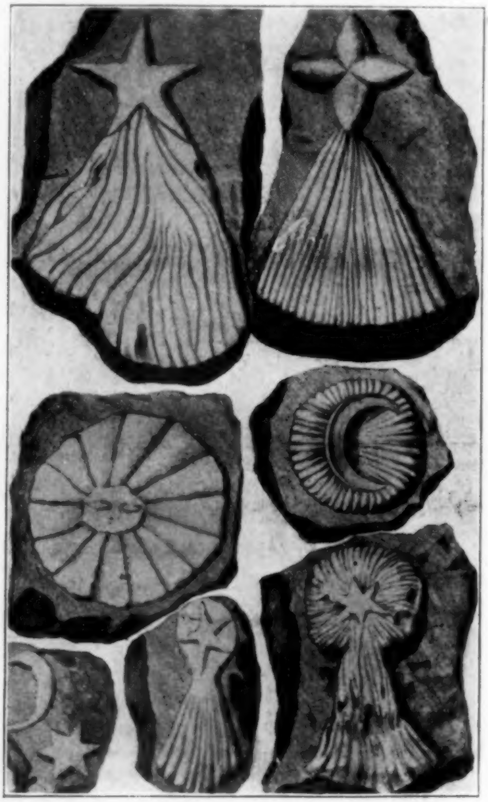

FIG. III.

agency in the formation of fossils be an important blow to purely secular science, but would undoubtedly at once and forever settle the troublous questions of the origin and meaning of fossil forms. No doubt the allegorical frontispiece idea came only after he had labored long upon the manuscript of his *Lithographiae* and had pondered over the enormous authority which it was to wield in the world of science and theology. In chapter after chapter, he anticipates and refutes objections to

his views concerning the *lapides figurati Wircebrugensis* or figured stones of Wurzburg, always reverting to his notion of their fabrication and concealment by the Creator. He describes gravely the Hebrew, Arabic and Syriac inscriptions which had been unearthed, commenting upon the nicety with which they were made and upon their excellent state of preservation. Some of these inscriptions occur on the representations of shells and other animal forms. The most surprising (and to Beringer the

FIG. IV.

most convincing) of these lettered fossils is one bearing the name of God Himself!

And now comes the strangest part of the story. Some of his friends, alarmed at the length to which Beringer was pursuing this prodigious fraud, endeavored to dissuade him from the publication of his book, and even though others, who knew the secret of the trick which was being so successfully played upon him, acquainted him fully with its shameful history, yet he ob-

stinately refused to give their stories credence. In one contemptuous chapter he dismisses all their evidence as a ruse by his rivals to deprive him of the honor of publishing the record of so great a discovery. And with a logic blinded by his vigorous faith, he argues that, since the workers employed by him to unearth the fossils knew no tongue save their own, they manifestly could not have made such inscriptions in Hebrew, Syriac, etc., as had been exhumed. Needless to say, he had first convinced

FIG. V. THE FOSSIL INSCRIPTIONS.

himself that no one save he and the workers, some young boys "of tender age," had ever seen the spot upon the mountain where he had discovered the marvelous insectiform stones.

His work being completed, in spite of the efforts of his colleagues and even of some of the townspeople, he published it and appealed to the learned world. But the shout of laughter with which the book was received was not to be misinterpreted. In chagrin, anger and despair, the broken-spirited man exhausted

virtually his entire fortune in the vain endeavor both to suppress the publication of the book and to buy back all of the copies which had been issued. For a short time he lived, the object of the mingled ridicule and pity of his fellow scientists and theologians, and not long afterwards died, as tradition tells us, of a broken heart! Carus says pathetically, "He later discovered the deception, endeavored to suppress the book, *und starb vor Kummer*."[4]

But the wrecking of Beringer's reputation did not cease with

FIG. VI. FOSSIL HEAVENLY BODIES.

his death, for a graceless book seller, Hobhard of Bamburg, bought up all of the available copies from the heir of the original publisher and not only reissued them, but compiling a second edition, brought out the work under a new title and turned this also into circulation![5]

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[4]Carus, *Geschichte der Zoologie,* München, 1872, p. 467 note.

[5]This second edition, while comparatively rare now, is not so rare as the original. A copy of the original is owned by the President White Library of Cornell University.

Beringer's woes have been great, and his demand upon posterity is one of large pity and not of unthinking ridicule. I can think of but very few of the great personages of history so in need of our heartfelt compassion as Johann Bartholomaeus Adam Beringer, Doctor of Philosophy and of Medicine in the University of Wurzburg, and private physician to the Prince Bishop.[6]

[6]For accounts of Beringer's work see: *Allgemeine Deutsche Biographie*, Vol. II; Ersch u. Grüber, *Encyclopädie d. Wiss. u. Künste*, Leipzig, 1818-90; Reusch, *Bibel u. Natur*, Freiburg, 1866; Reuss, *Litterarisches Curiosum*, Serapeum, for 1852, Vol. 13; Zöckler, *Geschichte d. Beziehungen zwischen Theologie u. Naturwissenschaft*, Gütersloh, 1879, Vol. II, p. 171.

USE OF THE HOME FARM IN AGRICULTURAL TEACHING.[1]

Many teachers of agriculture prefer to utilize the home farm in their teaching than to establish farms in connection with the school. This fact was brought out in the investigation of the committee on the use of land, working in connection with the American Association for the Advancement of Agricultural Teaching, which was referred to in the January number of this Monthly. The committee in a previous report stated that it "desires to go on record as strongly favoring the utmost utilization of the homeland of the pupils, the closest possible correlation of agricultural classroom instruction with home farm activities, and suitable provision for systematic and efficient supervision throughout the producing season."[2]

A number of states have planned home work as a definite part of the course in agriculture and many schools have caried on this work in a successful way. It is the aim of this article to show the point of view taken in some of the states and to give an idea of what is being done in this line of work.

Advocates of home farm work for students advance the following as some of the advantages of such work over that done upon the school farm: Agriculture may be taught successfully in small schools if the home farms are utilized, while it would necessitate establishing schools to serve larger areas if they are to have sufficient funds to establish and maintain school farms. There is a great advantage in having the boy live at home. It is argued that the adolescent youth is safer while living with his parents than he is while living at a boarding school. Many parents can afford to have their children attend school if they do not have to send them away from home. It is less expensive to board their children at home and they may have their services

[1]*From Agricultural Education Monthly*, U. S. Department of Agriculture, Office of Experiment Stations, Agricultural Education Service.
[2]*U. S. Bur. Ed. Bul. 601* (1914), p. 62.

outside of school hours. It is also less expensive to teach practical agriculture upon the home farm than to establish school farms. Home work is adapted to the particular condition under which the boy is now living and where he will likely spend his life. School work on the home farm affords an excellent opportunity to bring the home and the school together in educational problems. It also affords an opportunity for the testing of general results such as those worked out at the state colleges and experiment stations under strictly local conditions. The teacher of agriculture is given an opportunity to demonstrate that his teaching is practical. Such a demonstration wins the sympathy and loyalty of patrons in farm communities. Classroom and textbook instruction is worked out under actual farm conditions. The supervision of the instructor brings him in close personal touch with the student and his home environment; his teaching should become more vital with this association. In most of the work the boy develops judgment and a sense of responsibility which go a long way toward making him a man. He not only learns the practical application of the principles of agriculture, but he also learns the value of money, and what it represents in honest toil. One of the greatest lessons a boy has to learn in this commercial age is the value of a dollar; how to earn it, how to save it, and how to spend it wisely.

The phase of home work which we are to consider at this time is known as home-project work. Home projects may be correlated with club work and contests, but differ in that they are primarily a part of the regular school course in agriculture, and while financial rewards and other prizes may be gained, the chief rewards are the training the work itself gives and the school credit which represents it.

In Massachusetts, New York, Pennsylvania, New Jersey, and Indiana, a distinction is made between agriculture as ordinarily taught in elementary and high schools and vocational agriculture. Vocational agriculture is essentially of a practical nature intended for those students who have decided to become farmers. All of the states mentioned contribute state funds towards vocational teaching. Home projects considered are an essential part of vocational agriculture. The plan as worked out in Massachusetts is the result of applying the part-time idea in industrial training to vocational agriculture. The plan was first tried at Smith's Agricultural School, Northampton, Mass., in 1908-09. The annual report of the Massachusetts Board of Education for 1912-13

gives a list of four schools and eight departments which have been approved. While there were but sixty-nine pupils doing project work in 1912 and seventy-seven in 1913, 266 were admitted to such training for 1914. In 1913, thirty students while maintaining good standing in the classroom earned nearly $10,000 from farm work. (See *U. S. Bur. Ed. Bul. 579*, 1914, for an exposition of the Massachusetts plan.)

The following is from one of the bulletins of the Pennsylvania State Department of Public Instruction[3]:

"The project work is an essential part of the course of study. It is largely this work that places the agricultural instruction on a vocational basis. It furnishes the opportunity to connect the work of the school with the life of the farm, for the projects are usually carried out on the home farm rather than at the school. This close co-operation of the school and home increases the efficiency and service of the former as it brings it into closer touch with the daily home activities of the pupils.

"Most of the projects should be individual projects rather than group projects. There are some things that may be undertaken by the class as a group. This is true of some projects carried out on the school grounds, such as care of demonstration plats, test plats, beautifying of school grounds, concrete work, etc. But the principal projects should be carried on by the individuals of the class and usually on the home farm.

"A careful survey of the farm and home conditions of each pupil should be conducted by the teacher of agriculture before the selection of any project by the pupil, and in order that the hearty co-operation of the parent may be secured, frequent conferences between teacher, parent, and pupil should precede this selection of the project.

"One boy will undertake the entire care of a flock of poultry, having a definite aim in view in so doing. Another will wish to set out and care for a small orchard. The raising of a crop of corn will be the work of another. The survey and the conferences will be the means of determining the boy's choice.

"There shall be a close correlation between the work in the classroom and laboratory and the work connected with the project. A careful study of the work to be undertaken must precede the work itself.

"A report covering the work to be undertaken in a project, and giving the aim or purpose of the same, shall be submitted by the

[3]*Penn. Dept. Pub. Instr. Vocat. Div. Bul. 2* (1913), pp. 10-12.

teacher of agriculture to the Vocational Division of the Department of Public Instruction as soon as plans for project are prepared and before said project is started. This is in order that approval of said plans may be secured.

"A daily record will be kept by each pupil during the course of the project. The daily record will show amount of labor and money expended, methods employed, and results noted. This will include a daily weather record.

"A complete record is to be drawn up by each pupil when the project has been brought to a termination. These records are to be sent as promptly as possible to the Vocational Division of the Department of Public Instruction, as the approval of any school or department of agriculture will be withheld until evidence is presented that satisfactory project work has been carried on.

"Teachers of agriculture in agricultural schools or departments should be employed for a term of twelve months, as the most important part of their supervision and instruction is in connection with the project work, the greater part of which will be carried on during the growing season. This makes it imperative that the teacher of agriculture be employed during the summer months as well as during the period of the year when most of the school work is carried on.

"His summer work will consist of supervision of project work and instruction in connection therewith. His assistance should be as freely given to boys who are not enrolled in the school, but are carrying on project work, as it is to those who are enrolled in the school."

An idea of the New York point of view will be gained from the following quotation from a bulletin of the University of the State of New York[4]:

"The provision for an additional apportionment to each school which contracts with the teacher for an entire year makes possible an effective teaching plan. In these small schools many of the pupils return home each night and those who board in the village return home each Friday night. The home farms are used for demonstrations and practicums. The school furnishes an opportunity for a study of the science underlying the home work and related to it. Each pupil then has a productive project under way at home while in school he is studying the science underlying that project. It is expected that the parents, the boy, and the teacher will co-operate in this project, the parents and

[4]*Univ. State N. Y. Bul.* 566 (1914), p. 28.

the teacher each contributing to the educational possibilities of the boy and the boy taking advantage of these possibilities. Undoubtedly we have in some instances been too hasty in assuming that certain home opportunities for education have ceased to exist. During the spring and summer especially, there is splendid opportunity for the farm boy to make a real connection between the home and the school. It is quite evident then that the teacher should make frequent visits to the homes of the pupils in order that his advice and counsel may be available. The teacher of agriculture who spends the summer in close contact with the farm homes of the community goes back to the schoolroom in the fall with a much better idea of what and how to teach than he had previous to such an experience. During the summer the teacher has an opportunity to gather material of various kinds for his winter's work in the schoolroom. In passing about through the country he dispels some of the misconceptions concerning school agriculture and last, but not least, he puts his knowledge and skill at the disposal of the community.

"There have been varying and various ideas concerning the acquirement and use of land by schools of agriculture. Some states have included in the legislation concerning state aid, a stipulation that a certain minimum acreage of land be cultivated as a school farm. The consensus of opinion now seems to favor the use of home land as a first consideration and the use of land in connection with the school as a matter to be determined by local conditions."

The following regarding home work is from a publication of the Indiana Department of Public Instruction[5]:

"Each pupil in the day classes of the vocational agricultural school or department must select a line or lines of practical farm work to be pursued at home during winter and summer as an integral part of his course of study. The teacher must submit to the State Board of Education, within three weeks after the beginning of the school term, an outline of the home work to be pursued by each pupil. With each outline must be given the name, age, post office address, and general home conditions of the pupil who is to do the work.

"The projects for the winter months may consist in feeding swine, sheep, cattle, or poultry for market; feeding poultry for egg production; caring for a dairy cow and her products; caring for a team of horses or a brood sow; selecting, testing, and grading seeds for farm crops; poultry hatching, etc.

[5]*Dept. Pub. Instr. (Ind.) Ed. Pubs., Bul. 7* (1914), p. 13.

"Most of the above-named projects are suitable for summer. To these may be added corn growing, gardening, canning fruits and vegetables, marketing farm products, small fruit growing, etc.

"Both the winter and the summer project work must be personally supervised and inspected by the agricultural teacher. Each pupil must keep a careful record of his home work and must make a written report to be submitted to the State Board of Education upon the completion of the project."

A number of states which do not have separate vocational schools and which do not make home work a requirement for state aid appreciate the value of such work and advocate it for their high schools. The following is from a bulletin issued jointly by the State Department of Education, the University of Texas, and the Agricultural and Mechanical College of Texas[6]:

"There is great opportunity for the teacher of agriculture to accomplish valuable results with his students in so-called project work or part-time work. The term part-time indicates that part of the work of the student is done in school and part out of school. A certain project is undertaken by the students under the supervision of the teacher. The scientific principles involved are carefully studied, and plans are outlined in detail; the work is done, observations are made, notes are recorded, and a complete report of the project is submitted to the school. The student, assisted by the expert advice of his teacher, has put into practice on his own farm or on the school farm under a specific set of natural conditions, certain principles involved in his agricultural course.

"This sort of work is thoroughly practical and will serve to rob the pessimist's derisive 'book farming' of its stigma. Project work puts the boy into actual farm problems, where more or less expenditure of money is necessary and where incomes may be expected. School work assumes an appearance of business life that proves very attractive to the adolescent.

"Some project work could be completed during the school session, but much of it will continue into or through the summer. This makes it very important that the teacher should be employed for the year, so that he may supervise his students' projects during the summer as well as during the school session.

"The giving of school credit for project work is a matter that the individual teacher must work out for his school. Each agri-

[6]*Joint Bul. State Dept. Ed., Univ., Texas, Agr. and Mech. Col., Texas, No. 1* (1914), pp. 24, 25.

cultural subject may be made to include a certain amount of project work, just as it includes laboratory work. Credit in the subject may be withheld until the project has been finished and reported. An extra number of units for graduation may be adopted—eighteen instead of sixteen, for instance. The additional two units may be made by taking subjects in the curriculum, by doing some project work, or by doing some other work out of school, but with the approval and under the supervision of the school, such as music, art, printing, painting, etc. Still another method is to allow honor credits as special distinction for the students who have done work in addition to the work in the curriculum.

"The project work may be divided into three general classes—1, production; 2, demonstration; and 3, improvement. In some cases the project may include all of the features. A few examples of this kind of work are listed below. These will suggest many more.

"Production projects:

"1. Growing an acre of corn, cotton, tomatoes, potatoes, etc.
"2. Developing an acre of alfalfa.
"3. Starting an orchard—peaches, figs, plums, etc.
"4. Producing a berry patch—strawberries, blackberries, etc.
"5. Pruning, spraying, and managing an orchard.
"6. Care of a dairy cow.
"7. Care of twenty-five hens for egg production.
"8. Growing chicks for market.
"9. Care of brood sow and litter.

"Demonstration projects:

"1. Use of lime on land.
"2. Grafting and budding certain kinds of trees.
"3. Treatment of oats for smut.
"4. Treatment of potatoes for scab.
"5. Testing new varieties.
"6. Comparison of sprayed and unsprayed orchards.
"7. Comparison of different rations.
"8. Deep and shallow cultivation.

"Improvement projects:

"1. Developing a lawn.
"2. Planning and executing a landscape design.
"3. Cement work—walks, posts, troughs, etc.
"4. Replanning a farm.

"5. A plan for water system, bath, and sewage in farm home.

"6. Construction of buildings, gates, etc."

A Wisconsin University bulletin makes the following suggestions regarding home projects and their place in the high school course[7]:

"Instruction in agriculture differs materially from that of any other high school science in that much of the laboratory work must be done outside of school. Unless the theoretical instruction given is carried over into actual practice, the work in agriculture will lose much in effectiveness. This condition has given rise to the practice of employing the teacher of agriculture by the calendar rather than by the academic year for the joint purpose of supervising and assisting with home projects by students and co-operating with farmers in local field trial and demonstration work on their own land.

"There are three essentials to the success of a home project, viz.:

"I. Classroom study.

"II. Laboratory exercises at school relating thereto.

"III. Home work.

"Suggestive List of Home Projects.

"I. Plant Production.

"1. Potato culture, one-fourth to one acre, in potato districts.

"2. Alfalfa culture, one-twentieth to one-fourth acre, on upland soils.

"3. Clover growing, one-twentieth to one-fourth acre, on sandy soils.

"4. The production of one acre of all the cereals, each in itself a separate project.

"5. Establishing an orchard, on the home farm or in fruit region.

"6. The culture of one-twentieth to one acre of all the truck crops in the vicinity of good markets, each in itself a separate project.

"7. The production of a definite area of small fruits, each a separate project.

"II. Animal Husbandry:

"1. The keeping of feed and milk production records of the home herd.

[7] *Bul. Univ. Wis.*, *594* (1913), pp. 25-28.

"2. The calculation and feeding of improved rations, with records of results obtained from their use.

"3. The care and management of the home herd of cattle, sheep, or swine, each in itself a separate project.

"4. The care and management of the horses used on the farm.

"III. Soil Projects:

"1. Preparation of the land for the farm crops, each in itself a separate project.

"2. Soil fertility tests.

"3. Fertilizer plat trials.

"4. Laying out or installing a drainage project, or both combined."

A detailed outline suggestive of a home project in corn culture for an acre plat will be found also in this bulletin.

In Iowa, Home Work School Credit Clubs are organized and instructions issued from the state college regarding their work. Recent instruction sheets would indicate that the work is mostly with students of the elementary schools, but some specific projects are suggested for which high school credit is to be given.

A recent report on agriculture in the high schools of Michigan has the following concerning home projects[8]:

"In order that practice may be combined with theory, the classroom work and laboratory work done during the year is supplemented during the summer season by home projects. A list of suitable projects connected with the subject which has been studied during the year is placed before the students and each selects the project which he can best work out, or which may be of most interest in his home community. Boys and girls who live in town also select the projects and either work them out on a small scale on village lots or on land outside rented for this purpose. Some projects, of course, are not connected with crop raising, but are of a character which can be worked out at home or in the shop.

"The following will indicate the character of the projects which are being worked out during the summer season. The growing of the following crops: Corn, potatoes, alfalfa, and tomatoes. Also the care of an orchard of three acres; milk records of five cows; beautifying the home grounds; determining the cost of production of potatoes; the planting of a young orchard; growing one-fourth acre of cucumbers; care and development of poul-

[8] *Mich. Agr. Col., Dept. Agr. Ed. Bul. 13* (1914), p. 9.

try on the farm; growing four acres of corn. To these should be added projects for the girls: Baking, sewing, growing tomatoes, flower gardens, and small fruit culture.

"According to the statistical table approximately five hundred boys and girls who are connected with high schools are working out home projects during the summer of 1914. It should be stated in connection with the school at Ontonagon that this is a township district and the boys and girls of the entire township, which is half as large as the ordinary county, are engaged in this work.

"The home-project work has its intensely practical educational value and at the same time it is distinctly vocational. Frequently it will assist the boy to determine the question whether he desires to become a farmer. The actual commercial value of the products to be raised, of course, can not be stated at this time, and as this is the first year since home projects have been particularly recommended we are unable to give any figures as to the value of the products. The working out of the home project always develops a deeper interest in agriculture, and a keener insight and appreciation of the processes and the purposes of farm operations."

The following is from the superintendent of one of the schools of agriculture in Minnesota[9]:

"School farm demonstration work alone does not cover the entire work with land. What the school farm can seek to do has been pointed out. Naturally, the field is a restricted one. The limitations of the work have been realized by many who wish to extend the benefits of high school agricultural teaching as widely as possible. They have turned to other plans to supplement the work of the school farm. Home-project work, both for demonstrational and for practical purposes, as well as work on the farmers' own farms under direction of the agricultural teacher, is the means employed. The work is new. Out of nearly 150 replies received, only about a dozen report that home-project work was required during the last season. Most of them say, however, that they 'intend to require it,' or that 'it will be encouraged,' or 'it will be optional.' Those schools that have begun home-project work state that it is their most successful venture. Several schools report that they have given up their school land and have substituted home-project work and work with farmers on their farms instead. Several new schools, just beginning, are hesitating between the school farm and this other plan.

[9] *U. S. Bur. Ed. Bul. 601* (1914), p. 14.

"After two years of experience with home projects, I am confident it will become a very effective work when it is properly organized. Every line of demonstrational work that can be carried on on the school farm can be made a home project. It has greater value if done by a farmer's boy at his home than if done at the school farm. Persons who have thought much about the psychology of demonstrational work know that such work done by the National Government, the state experiment stations, or the schools has less effect than if done on actual farms by farmers themselves.

"If alfalfa is a good crop to grow, it is advisable to have it grown on the home farms as well as on the school farm. Landless boys can be allowed to use the school farm in lieu of land of their own. The home-product work will naturally include other lines than work involving the use of land, but these lie outside the scope of this discussion. The projects should be graded very carefully and choice allowed between groups requiring equal work. Cost accounting, a complicated subject in school farm work, which is, however, a most important item in agricultural production, can easily be secured in individual home-project work."

The Agricultural College Extension Department of the University of Illinois has issued a circular giving suggestive projects: *Home Projects for School Agriculture, Agr. Col. Ext. Univ. Ill.* (Circ.), 1913, Mar.

TESTING OF GLASS VOLUMETRIC APPARATUS.

Circular No. 9, entitled *The Testing of Glass Volumetric Apparatus,* of the Bureau of Standards, Department of Commerce, has just been published in a revised form, specifications havnig been added for several new graduates for weights and measures inspectors. ,

The circular contains specifications for glass volumetric apparatus, including burettes, pipettes, flasks, cylindrical graduates, specific gravity flasks for Portland cement, Babcock test bottles, etc.

Copies of the publication may be obtained without charge upon request to the Bureau of Standards, Washington, D. C.

"BOOST MATHEMATICS."

By Sara B. F. Rabourn,
High School, Visalia, California.

Would that teachers of mathematics were able to glean a lesson from the citizens of California! Their slogan is "Boost California." They believe in their state, have faith in their climate and natural resources, and possess a sense of state loyalty and state patriotism that is equaled only by the Germans in their love for their Fatherland. No citizen of Rome ever displayed more pride in saying, "I am a Roman," than the present-day native son displays when he proclaims to the world, "I am a Californian."

It is something of this same spirit that teachers of mathematics should possess. They have a right to feel proud of their domain of work and to boost its value. Filled with loyalty for their subject, they should be happy to assert that they are teachers of mathematics; and glowing with enthusiasm, they should aim to attract others to the pursuit of mathematics. Theirs is a historic and stately mansion of many chambers, set in the fields of a rich estate heavily endowed by nature and backed by a splendid ancestry. It is not given everyone to occupy this house of mathematics. The occupants are, indeed, few. It is the high mission of teachers of mathematics to increase the dwellers and owners of this estate so that larger numbers may become heirs of the wondrously rich heritage of the past and shareholders of the untold discoveries of the future.

Teachers of mathematics taking up their abode in the dignified mansion will have time for serious reflection upon the intrinsic worth of mathematics, and thereby will acquire the larger vision and the means of enlightening the masses upon its unique value. They can summon the historian who will testify that the race of man owes its most precious truths to mathematics, and the real mathematician who will say that mathematics is the very essence of fundamental reality; that it forms the basis for all rigorous thinking; that the underlying mathematical ideas or concepts are omnipresent in our thinking everywhere. Perhaps he will speak of the influence of mathematical thought on logic, psychology, ethics, theology, jurisprudence, and art; and no doubt will show that the ideas of function, group, invariant, limit, and infinity belong not only to mathematics but to thought in general. It is the duty of teachers of mathematics to make the masses sense

this value of mathematics. Does not the notion of limit pervade the whole of our mental life? What is an ideal, but a limit, something unobtainable, but always to be aspired to? The other notions mentioned are also felt consciously and unconsciously everywhere in our lives. The idea of invariance plays a large part in human thought. History shows that man's eternal quest has been for something permanent, invariant in this world of change.

Although mathematics is an exact science and its content often theoretical and technical, it is teeming with human interest for those who will invade its sacred domains. Those teachers who grasp a few of its many possibilities and are inspired by a glimpse of the "vision splendid" will wax enthusiastic over its beauties, depths, and mysteries; and in their efforts to humanize their teaching will be ever mindful of the wondrous splendors of mathematics that have the power to fascinate the whole mind. They will be familiar with the various reasons for studying mathematics, whether it is studied because of its practical and utilitarian value or for its application in science, or for its own sake or for its relation to thought in general or because of its power to train human beings to think accurately and logically.

The teacher of mathematics who possesses the broad outlook will be able to deduce from these the necessary and sufficient reasons for studying mathematics. To satisfy the growing demand that a subject must be practical in order to retain its place in the high school curriculum, they will have only to cite the great engineering works of the past and present, made possible by the applications of mathematics. Indeed, mathematics has laid the foundation for our material civilization. It now stands as the steel framework of the structure; take it away, and the edifice would totter, crumble, and fall in hopeless ruins.

Again, the teacher of mathematics may call the attention of those seeking utility values to the great debt pursuers of the physical science owe to mathematics. From this we see that mathematics is a tool; but it hurts the real mathematician to hear it classed as nothing but a tool. There are those who argue that mathematics should be taught only as a preparation for college or at most to those who wish to take up engineering or scientific work. How sickening to the heart of the true teacher of mathematics! He is more disposed to agree with Jacobi that the "unique end of science is the honor of the human spirit." Mention has already been made of the influence that mathematics has on all forms of

human thought. This, alone, should give it an unquestioned place in the high school curriculum. Emphasis should be placed on the reason that mathematics is studied or taught for its training in the high art of logical thinking. There are a few teachers, and may their numbers increase, who have so great faith in their subject that they see springing up in the future a great race of thinkers who ascribe their wonderful power to the study of mathematics. Surely, the world was never more sadly in need of thinkers than at the present time. One hears on every hand the cry, "It is not more power that we need, but ideas." The theories and observations of a western university professor place the ratio of thinkers at only two in every twenty-five thousand. Alarming as this statement is, we shall have to admit its partial truth.

The time is propitious for the high school to take a serious inventory of its courses to find out what it is offering the rising generation that will teach it to think. Down with the faddists and quacks who have held full sway in their reign of slaughter, experimenting, and innovations. The pendulum has swung far enough in the direction of the commercial and vocational subjects; it must come back to normal. Harmonious equilibrium of the solids and vocational subjects must be preserved. It must be admitted that with the overcrowded course of study and the highly elastic, elective system, most of our boys and girls are receiving a very superficial education and little or no training in the fine art of thinking.

What can teachers of mathematics do? Are they going to sit idly by and permit mathematics, the one subject which has the power to develop rigorous thinking, to be crowded out of the high school curriculum and relegated to the scrap heap along with the classics? Are they going to be partisans to the absurd fancy of the age that people can not be happy and think? No, indeed no, they are going to put on their fighting armor and sally forth to the front, into the trenches if need be, and demand that mathematics hold its rightful place in the high school curriculum against all future onslaughts, for they know that the mathematically-trained mind is needed in all forms of human endeavor, that the subject of mathematics properly taught will give pupils mental strength and power to help choose things worth doing.

Mathematics should appeal to all classes. It has a highly cultural and æsthetic value, a noble spiritual value, and a most

decided practical value, not only because of its practical applications to engineering and the sciences, but because of its practical value in training people to think. Surely, no one will brand that subject as not practical which gives training in the high art of thinking. We know that a country is not saved by spasms but by men who can think straight. We live in a day when people must not make mistakes in crises and pay the penalty. The world is full of the tragedies of wrong decision. What subject, asks the teacher of mathematics, gives more power in forming quick and accurate judgments and greater ability in drawing necessary conclusions than mathematics? This power, he will say, is practical.

Mr. G. K. Chesterton throws an interesting light on the value of the so-called practical man in time of a crisis. According to him, when things go wrong we do not need the practical man, the man who is accustomed to mere daily practice and the way things commonly work, but the theorist, the thinker, the man who has some doctrine about why things work at all. Indeed, there is placed a high utilitarian value on the man with ideas who can prevent a crisis. Sometimes impulse and instinct will save a situation but the hero of the occasion is most often found to be the person who has been trained to think accurately and logically. Teachers of mathematics contend that their subject is best suited to give this training.

The aim of the first part of the thesis has been to inspire confidence in high school teachers of mathematics for their subject and to give them courage to "boost" the wonderful superiority of the mathematical province. Thus equipped with confidence and courage, what are they doing to humanize their teaching? What efforts are they making to attract students to their courses? Why does mathematics get the reputation of being nothing but dry bones? Why is it so often classed as a subject which only grinds take delight in? These and similar questions teachers of mathematics may ask themselves. They also can submit themselves to cross-examination. Are they as teachers of mathematics doing their duty? Has their enthusiasm for mathematics reached the *n*th degree? Are they always striving to awaken a new and palpitating interest in their subject? Do they realize that such a body of thought which penetrates and colors all thought admits of manifold humanizing interpretations? A vital touch here, the waving of the magic wand yonder, will take pupils away from time-worn, beaten paths into new ones where charming vistas will reveal an enchanted land which they will be eager to explore.

If every teacher of mathematics fulfilled his mission, the number of students in the elective courses of mathematics would be astoundingly increased. Records show that students pursue other subjects that are not in themselves more attractive or more capable of awakening human interest. It is legitimate to employ means to inspire pupils with the desire to study mathematics and to create an appreciation of its intrinsic worth.

Numerous are the stimulating devices to which they may have recourse. Even high school pupils have not outgrown the play instinct. They do not learn less geometry or learn to reason less accurately when one day they consider their geometry lesson a game, themselves the players, the axioms and definitions the rules of the game, and the teacher as the umpire, referee, grand-stand spectator, and side-line fan, all in one; or on another day when they become mechanics and architects and from the hypotheses of the given proposition they erect a splendid edifice, making each statement and reason in the proof imperative for the finished structure, just as each stone and brick and brace are necessary to make a safe and strong building. The final conclusion of the logical proof is similar to the roof or cupola or crowning summit of the building.

The geometrical constructions and designs serve as a legitimate means of quickening the interest. The pupils take delight in designing church windows and in drawing patterns for linoleum and tiles for flooring. If the school has a lantern it can be used effectively to throw on the screen examples of architecture, embodying the mathematical figures that have been studied. My experience has been that often a lad is inspired to copy the rose window of Westminster Abbey or the tiled floor of the Sistine Chapel or that of St. Mark's or the arches of the Doge's Palace. The Colosseum, the Pantheon, and the dome of St. Peter's never fail to bring forth applause. These lantern lectures give room for bits of history and afford opportunities for emphasizing the mathematical character of art and architecture. My pupils like to class Michael Angelo as a mathematician. They see in him not only the greatest of artists and sculptors and architects but a man who thought in mathematical concepts.

All through the work there is an abundant opportunity for developing the history of mathematics. This never fails to stimulate the interest. The lives of some mathematicians read like pages of a romance or a Grimm's fairy tale.

Often it is possible to create a feeling for some of the higher

forms of mathematical thought and to indicate their influence on thought in general. Numerous examples of the idea of function can be cited. The circle as the limit of circumscribed and inscribed polygons means much more to pupils when they think of the circle as the ideal of the polygon. Just as their highest ideals are limits which they can never reach but only aspire to, so the polygon can never be a circle, but as its number of sides is increased, it can come nearer and nearer to the goal of its ambition, its ideal.

Many other mathematical ideas, teeming with human interest, can be utilized that will serve to attract students to mathematical courses and to create in them a healthy and abiding interest—an interest that will cause them to explore more and more the wondrous beauties and truths of mathematics. A superficial veneer must be avoided. Not one iota of the logical character of mathematics must be sacrificed, lest its high value become ineffective. There must be inculcated in the young ones a love of truth for truth's sake and, above all, a desire to think.

In this kaleidoscopic age when people are subjects of queen motion picture there is a very great danger of their becoming too dependent on the visible and the tangible and so absorbed in the power of visualizing that they lose their power to think. Teachers of mathematics must endeavor the harder to attract pupils to their courses and teach them to think in spite of themselves.

The task is difficult; the purpose is opposed at every turn. It would seem that all forces were in league to prevent pupils from thinking. Some of the methods of the opposing forces can be used to advantage in attracting children to the study of mathematics. A lesson can be learned from the merchant, the business man, the professional man, the showman, the churchman, that it pays to advertise. Having faith in what they offer, they put it up in the most attractive form, advertise it, and induce people to take it.

I have tried to carry out the same idea in my work. I believe I am teaching one of the most important subjects and I try to make pupils feel that they miss something if they do not study mathematics. We have red-letter days and advertise them on the bulletin board. Mathematical posters are sometimes in evidence. Another time drawings and models are on display, as much laboratory work is done. Boosting articles appear in the weekly school paper.

In our high school the weekly assembly programs were fur-

nished by the four classes. In addition there had been programs by English classes and there was talk of a Spanish program and a German program. Why not a mathematical program? I proposed the same to my classes. They seemed doubtful of their ability to entertain the school. After the possibilities of the program were discussed, they took up the idea enthusiastically and the result was an excellent entertainment. They called their effort, "The Modern School of Athens," and worked it up after the manner of the Dialogues of Plato.

When the curtain rises, the Master is discovered walking in the portico, expounding some of the wonders of mathematics. His pupils come in turn, one discourses on the properties of the magic square, another discusses the limitations imposed upon races of beings inhabiting a one-, a two-, and a three-dimensional space and therefore develops the layman's point of view of fourth dimension. Still another delights the audience with some interesting old puzzles and paradoxes. A girl gives her views on "The Value of Mathematics to Girls." There follows a humorous debate on the "Circle versus Square." The school breaks up in confusion as the revelers from the market place invade the sacred precincts. The Master is persuaded to let the joy-makers give exhibitions of the round and square dances as a final means of deciding between the square and the circle. As they finish the dances, the curtain falls, leaving the audience to decide the all momentous question.

Does it pay to advertise? Yes. The present senior class in mathematics is twice as large as the one of last year and the other classes have shown a marked increase in enrollment. In trying to humanize my teaching, I have endeavored to keep sight of the nature of mathematics. I know it is an exact science and that its worth will be valueless if it loses its logical character.

I boost my subject and I try to attract students to my classes. I have felt justified in persuading a girl to study mathematics instead of second- or third-year domestic science. There are those who oppose teaching girls mathematics beyond the mere rudiments. If one would listen to the arguments of the opposition, he would almost conclude that there was something in a girl's biological make-up that prevented her from learning mathematics. The life and work of the great Sonya Kovalevsky give one instance that will refute this argument. If mathematics is presented in a humanizing way to a girl, it can be of great value to her. The girls need to be trained to think logically just as well as boys.

Education should be not only to train people how to make a living, but how to live. When persons stress the value of the vocational subjects instead of that of the three R's, I like to quote Sir Oliver Lodge: "It is not bread alone that man needs; he should have leisure to cultivate his soul and education should assist him. Machinery may contribute to subsistence, machinery from the plow upwards is necessary for that, but wealth of soul is not increased by machinery."

Let us conclude with three rousing cheers for mathematics, a subject that does double duty. In its rôle of utilitarian and philanthropist, it has given much to the world's material wealth and contributed much to the world's subsistence; but it has done, yea, even more. Possessed of an æsthetic, cultural, and spiritual value, it has been the great and sustaining helper of the human intellect in its onward march to the Platonic ideal of harmony.

ANALYTIC METHODS IN ELEMENTARY GEOMETRY.[1]

By Emily E. Dobbin,

Mechanic Arts High School, St. Paul, Minn.

Every educational activity falls under one of the two categories—the acquisition of knowledge, or the development of the natural powers, physical, mental or moral. Knowledge is acquired by the use of the human faculties, and the faculties are developed with the acquisition of knowledge. The two processes interplay, but are equally essential.

Most of the arguments concerning details of methods in education have as a fulcrum the question of the relative importance of these two claims in education. Which is the more important, knowledge, or the power to utilize knowledge? And the answer usually depends upon the degree of utilitarianism directing the discussion.

These statements concerning general education are nicely applicable to the particular department of learning generally known as mathematics. The changes in methods and in subject-matter, sometimes advances, sometimes retrogressions, have all depended upon the average conception of the usability of the subject in practical, everyday affairs. At present the conflict between practice and theory is very clearly defined in the difference between the mathematics taught in the engineering and aca-

[1]Read before the Mathematics Section of the Minnesota State Teachers' Association at Minneapolis, October 29, 1915.

demic sections in colleges. These distinctions are reflected in the varying methods of preparation for different professions in high school curricula. This difference is even more sharply evident in the elimination of much mathematical training from the business and general courses in our intermediate schools.

So the crux of the situation seems as ever to rest upon the decision of what the youth needs more, knowledge of facts directly usable in his chosen life business, or ability to use any and all kinds of knowledge. This ability to use knowledge is generally applied to the solution of a problem presented in concrete form in terms of one's extraordinary experiences. Frequent, ordinary experiences are easily taken care of by the routine and habits of life. But unusual experiences present the new problems. The training which should prepare for the solution of financial, commercial, moral, or ethical questions that arise in adult life, is evidently then more than a technical training in the especial subject-matter of one's profession or business.

Measured by this broader set of standards, in how far are we justified in presenting to high school students who may never have a formal opportunity to achieve further preparation for life's perplexities and complexities, any subject as classical, as stereotyped, as hard-and-fastly synthetic, as is the geometry taught in the public schools of the United States, from almost literal translations of the *Elements of Euclid* collated about 300 B. C.? Great Britain and the United States are almost unique in that they continue the teaching of Euclidean geometry, with no touch of analytic geometry until university or college is reached. In the last decade England has gotten away from the traditional sufficiently to alternate *Euclid* with Spencer's *Inventional Geometry,* which is analytic in method.

In very general, nontechnical terms which may appeal to the experiences of the high school youths, analytic reasoning may be called the process of starting out with some known truths, concentrating thought upon these, with no knowledge of a previous statement of conclusions to be drawn, by direct process of reasoning, arriving at a result or conclusion. If the premises are truths, and the reasoning correct, the result will be the deduction of new truths, or more truth. Synthetic reasoning can be generally defined as the process of reasoning from some known or accepted facts, by supposedly correct methods and processes to the re-establishment of a conclusion already known to be true.

The contrast between the two methods, as we shall call them, in spite of the fact that many philosophers look upon them as only parts of one reasoning process, may be carried out by an illustration from algebra. The problem is stated, studied, analyzed, put into the form of an algebraic equation, and solved, all by analytic reasoning. The answer once obtained is substituted in the original equation and proved correct by synthetic reasoning. A beginning class in geometry can immediately consider which method is used in the various professions, and which serves better the various needs of life. A discussion always brings out the idea that a lawyer is analyzing when he undertakes a case and studies it, but synthesizing when he presents his case to judge or jury. High school students know that it is the business of each client's lawyer to convince the third party he is right. They also know both parties to a legal conflict can not be right, and they see very clearly that the error will be in the analysis of one attorney, the one on the wrong side of the case. But they also perceive that once committed to a case, the synthetic reasoning of each may be perfect, though directly opposed in the conclusions they wish to establish as facts.

These young people can always apply the terms to the work of the medical practitioner. They say that the physician in studying and diagnosing a patient's case is analyzing, but after getting the facts together, he assumes them to be caused by a certain malady, and believing this from his own and other experiences, he sets about the cure synthetically. They are also able and willing to apply the terms to the practices of the soul's physician, the clergyman, and to the engineer, and those in various other callings.

In a discussion of the reasoning processes involved in financial and commercial pursuits, one may be astounded to find that few high school pupils think business men guilty of any kind of thinking at all. The young person seems to consider business is now carried on by application of a cut-and-dried set of rules, unchangeable, and automatically running things. This state of mind seems an index finger, pointing to the need of more conscious intelligence applied to business conducted in our present-day civilization.

As you can readily see the class has by this time made out a pretty strong case for analysis, apparently against synthesis, in training the young and growing mind for life's later duties. But here is the opportunity for the wise guide and director of debate

to show the superiority of purposeful thinking, which is synthetic. The pendulum can soon be swung back from an extreme championship of analytic reasoning to a clear understanding that both are necessary to the successful thinking out of any achievement.

Such preliminary discussions can be followed by occasional reviews of the principal ideas during the term's work, accompanied by illustrations of acute analytic attacks upon original exercises. The theorems which are stated classically are not to be deposed, but supplemented by analytic work when occasion arises. Not only can this be done by means of original exercises, but by reference to analogies between geometric theorems and algebraic problems. For instance, the construction of a rectangle under certain conditions, as area and sum of two sides given, is analogous to the set of algebraic equations, $x+y=a$, and $xy=b$, treated simultaneously. Also, area and difference of two sides given is analogous to the pair of equations, $x-y=a$ and $xy=b$. The instructor, who knows arithmetic, algebra and geometry as the science of quantity and magnitude, will find no scarcity of material for this kind of illustration. The graph might well be used along with this work, if the time allotted for the study of geometry permitted it. As a matter of method one would have to be very careful not to create confusion by its introduction in geometry in a crowded course. Its omission would be better than insufficient study. But the interplay between algebra and geometry, between analysis and synthesis, can be continued all through the mathematics course by using the graph in algebra, thus keeping geometry in mind at that time in the student's development. So the correlation begun in elementary geometry can be continued throughout the later work in algebra, assuming the course continued in the junior and senior years, to include advanced algebra.

Let us depart from the strict interpretation of the topic to extend the ideas to broader realms. After all, what is the greatest value to the ordinary, nontechnical adult of the years spent in mathematical labors? Aside from the purely intellectual pleasure a few may enjoy, the value is surely in the training of the so-called reasoning powers. Is not this greatly augmented, or rather would it not be, if the student were aware of his mental processes; if the instructor deliberately trained in very deliberate, thoroughly self-conscious thinking, both analytic and synthetic? And could not this training be followed by more

correct mental application to the real, practical problems of life itself?

Here lies one of the greatest responsibilities of public schools. To teach the difference between drifting with events and controlling events, to show how control can be obtained and exercised, and when necessary, is surely an important function of the public school system of a proclaimed democracy. Our citizens need training in thinking processes, in studying the present results of past events, and the future outcome of present tendencies. Is there not something wrong with the business world? If not, why do we create so much and have so little? Why work so hard, and live so poorly? This is more than an individual problem, it is a national problem, and will not be solved until many minds are concentrated on right thinking upon it, analyzing the situation, and uniting to work towards some end which is worth while.

Our national future is difficult to foresee, but it does and will depend upon the will of the masses, as never before in the world's history has any nation's depended upon large numbers of minds and wills co-operating. For the mass have the power here and now. Whether they use this power wisely and insure our preservation, or rashly hurl us on to destruction by the governmental policies, political outcomes, financial and commercial methods which will survive, is to depend upon the ability to think clearly and right in large masses, among the aggregate as well as the average citizen. This citizen is now being moulded in a large extent in our high schools. Is he obtaining power, or simply learning to prove again a few statements which have been known to be true since 300 B. C., 2,200 years ago?

A SIMPLE GEOMETRICAL PROOF OF THE LAW OF TANGENTS.

By Clifford N. Mills,
South Dakota State College.

I have read with much interest the articles by R. W. Mathews and E. R. Hedrick, which appeared in the December, 1915, and April, 1916, issues of School Science and Mathematics.

The following proof has been used by the writer, and it is directly associated with the geometrical meaning of the tangent. Hence it is best to use a construction which will show the tangents of the angles 1/2 (A+B) and 1/2 (A—B) as tangents to a circle. It has been my experience to find that very little confusion has come about by using this method, and my students seemed pleased to use it. The small number of lines in the figure makes the analysis easy.

This method I find in an old textbook on trigonometry.

$$\text{To prove } \frac{a+b}{a-b}=\frac{\tan 1/2\ (A+B)}{\tan 1/2\ (A-B)}.$$

Given any triangle, ABC. Produce AC to D, making CD = CB and join DB. Take CE = CA. Draw AE and produce to F. Then AD = $(a+b)$, and EB = $(a-b)$. $\angle$DAF — 1/2 (A+B) and $\angle$FAB = 1/2 (A—B).

The triangles DAF and BEF are similar. AF is perpendicular to DB. With A as a center and AF as a radius, describe an arc of a circle; then $\frac{DF}{AF}$ will be the tangent of the angle DAF, and $\frac{BF}{AF}$ will be the tangent of the angle FAB.

From the similar triangles DAF and BEF, we get the proportion:

$$AD : BE = DF : BF.$$

$$\text{Hence, } \frac{a+b}{a-b}=\frac{\tan 1/2\ (A+B)}{\tan 1/2\ (A-B)}.$$

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THE PLACE OF MATHEMATICS IN THE "SECONDARY SCHOOLS OF TOMORROW."[1]

In this period of adjustment of the secondary school curriculum to the needs of the students, it is not possible to predict the position that the various subjects will ultimately occupy in the general scheme of secondary education. A subject is either contending for a place or fighting to maintain its traditional position. It is a case of the survival of the fit. It is important that this orientation be brought about as soon as possible. The members of the Mathematics Club of the City of Chicago[1], believing that well-defined evidence points to certain definite, crystallizing characteristics in the teaching of secondary mathematics, submit the following views and suggestions to the teaching public.

1. The student should and will come to the consideration of secondary school mathematics much younger than heretofore. The elementary school arithmetic courses are being carefully surveyed with the purpose of ejecting extraneous material, thus placing the emphasis on the minimum fundamental essentials of arithmetic. Assuming that the primary grades by means of informal games and other familiar devices inculcate fundamental number combinations, the fundamental essentials of arithmetic may be thoroughly taught in four or, at most, five years. The facts submitted by certain schools no longer permit us to regard this as an experiment.

2. (*a*). At least one year of mathematics should be required of all secondary school students. This course will not be designed to meet merely college entrance requirements, as in the past, but to meet the needs of a variety of institutions ranging from those connected with large industrial organizations to the university. It may be a general introduction to the field of mathematics. It may be termed a culture course in mathematics It will be a course of mathematics, not a course about mathematics. On the content side, it will enable the student to use the simpler forms of the equation, to interpret statistical material graphically, to understand the uses of a formula, to interpret a wealth of illustrative geometrical material, and to generalize and make meaningful the arithmetic. It may also include practical devices, *e. g.*, trigonomet-

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[1] For two years, a number of mathematics teachers in Chicago and vicinity have met once a month during the school year, for purposes of personal acquaintance and for the consideration of questions of professional interest. Out of the discussions grew a desire to state in somewhat definite form the convictions of the members of the club on some of the new educational aims and tendencies in the field of mathematics. This tentative report of the committee after considerable discussion is published as a basis for further investigation and deliberation.—*Math. Ed.*

ric ratios, logarithms, the slide rule, etc., as tools for solving the practical type of problem.

(*b*). The course will be taught by thoroughly trained teachers. Critics of the results of teaching of mathematics have not always realized this. Criticisms of mathematics are frequently unconsciously directed against the training of mathematics teachers. Administrators are beginning to realize that the teaching of mathematics requires the command of a special technique. The "farming out" of mathematics classes to teachers who have no love for the subject and no special training for teaching it will cease. School executives will insist that a beginning teacher of mathematics possess not only reasonable command of the subject matter, but experience in expertly supervised practice teaching. It can be statistically proved that scientifically trained teachers of mathematics under standard conditions have very few failures in rigorous courses, and that their students pursue the subject with a high degree of pleasure.

(*c*). The fact that all courses in mathematics beyond the introductory courses are elective will not materially decrease the number of students who study mathematics. The University of Chicago High School has for a considerable number of years required only one unit in mathematics. This school sends approximately fifteen students per year to colleges which require at least two and a half years of mathematics. At present there are 342 out of 420 registering in mathematics. Of the seventy-eight not taking mathematics, twenty-nine were discouraged from the further pursuit of mathematics because the mathematics faculty believed they could pursue other subjects with greater profit. Still others came from other institutions and did not see fit to take up the subject anew. The public high schools of Chicago require but one unit of mathematics. Here, too, the situation is equally encouraging. At Hyde Park High School, for instance, 1,450 out of 2,400 are enrolled in mathematics classes. This means that 700 are electing the subject. Quantitative thinking and precise expression of this form of thinking constitute so fundamental an element in the lives of boys and girls of high school age that the voluntary continuation of this study is assured if the introduction has been properly presented.

3. Mathematics will function in the following specific ways in the lives of secondary school students:

(*a*). As a means of generalizing arithmetical processes. The experienced teacher does not harangue about his students not

knowing their arithmetic. He is satisfied to have them know the merest essentials of arithmetic, for he knows that his students need the generalization afforded by an algebraic treatment of these processes. Laws of areas, perimeters, interest, percentage, and forces are simplified and given a fuller interpretation by the use of the equation. The fundamental operations applied to fractions, particularly decimal fractions, even though they may be performed with a high degree of efficiency, come to have a fuller meaning in the form in which they are constantly involved in formulas and graphs. The correlation is so high that the critic who argues against the teaching of the essentials of algebra appears to be debating the desirability of generalizing the laws of arithmetic.

(*b*). In this complex mechanical age, the shopman may hope to rise above being forever a part of the machine he operates, only through his ability to read the literature dealing with the process or his ability to interpret intelligently general instructions. These instructions are extremely formal, being usually expressed in complex formulas. The cry of the shop is for more mathematics. It is not yet clear what form shop mathematics will take, but the shopmen insist that the problem is one of putting a very advanced type of mathematics into a very simple form. No twelve-year-old boy ought to have this probable avenue of promotion cut off. In this connection, it is interesting to note that certain critics of the practical value of secondary mathematics have recently attempted to write a "cracker barrel" type of arithmetic to meet the needs of the shop, with the result that their efforts have not been taken seriously by shopmen. It is just possible that a general course, emphasizing the use of the simple equation and formula along with the elementary principles of geometry and trigonometry, will prove the best preparation for vocational courses. At present, the shop instructors must assume the problem at this point and teach the mathematics from this point as an integral part of the shop work.

(*c*). As a means to prepare secondary school students to pursue intelligently the study of the physiological, biological and sociological sciences. Here it is important to recognize that the field of subject matter involved is far more extensive and consequently affects a greater number of secondary school students than is commonly realized. It is a fact that mathematics is an essential prerequisite to courses in scientific agriculture, engineering, physics, chemistry, art (drawing, designing, architecture,

modeling, life and still life drawing, handicraft), pharmacy, dentistry, navigation, astronomy, naval and military engineering, domestic science, insurance, forestry, commerce and administration (use of graph and formula in reputable institutions) and railway administration. To this list we must add certain courses that are becoming more and more statistical, *i. e.*, more scientific, as for example, political economy, sociology, hygiene, sanitation and education. Visits to the various commercial clubs and reading the literature of trade journals impress us with the extensive use of the graph and the formula (the two most important topics of secondary mathematics) in the business world. Furthermore, this organization would add to this list medicine and journalism. Although some prominent educators assert that secondary mathematics is not essential to medicine and journalism, we have not yet discovered a reputable physician or surgeon who is willing to consider seriously such remarks with reference to their needs. It is difficult to see how a student with no training in mathematics could pursue the Science courses in his preparatory years, much less read the technical literature while engaged in practice. Suffice it to say that medical schools in both Classes A and B insist that mathematics shall be prerequisite. We shall discuss the relation of mathematics to journalism in another connection. Traditionally, it has been held that while the subject matter does not directly meet the needs of such professions as law and theology, nevertheless the method of attacking a problem obtained in the study of mathematics is essential. At any rate, the statistical investigations show a positive coefficient of correlation between success in mathematics and law. Perhaps this is only due to mathematics being a highly efficient tool to eliminate poor material in legal student bodies. This in itself may be a valuable function, for society certainly needs to recruit its lawyers and theologians from our best minds. German schools frankly recognize the value of an eliminative factor in the process of gaining professional efficiency.

Nor are we concerned only with the ever-increasing number of secondary school students who pursue these subjects in higher educational institutions. Universal education is the order of the day. These courses are being offered in community centers, evening schools, correspondence schools, extension departments, and in unorganized form by the public press. The successful citizen of the next generation will find it necessary to be able to interpret scientific literature dealing with his special field.

(*d*) As a means of interpreting human experience. This means development of space and pictorial imagination, *i. e.*, the appreciation of the dependence of one magnitude upon another. The existence of this dependence falls within the experience of every student. It is especially valuable for those who cannot go beyond high school. Quantitative thinking and the technique of quantitative expression play a far larger part in human experience than current opinion realizes. Current magazines and the daily papers include a very large proportion of mathematical terms and concepts, the meaning of which must be clear in order to be appreciated. A committee recently attempted to collect for purposes of exhibition the mathematical references found in the Chicago daily papers. In a few weeks, the abundance of material collected, whose full significance depended upon the clearness of the mathematical concepts and terms involved, made the task a hopeless one. If the reader will mark the mathematical material found in a single representative paper for a period of a month, he will be overwhelmingly convinced that human experience and mathematical concepts are very closely correlated. Furthermore, he will also be convinced that a considerable number of journalists have reasonably clear ideas of mathematical concepts, and perhaps he would insist that mathematics be requisite for future journalists, if they are to interpret properly human experience and discuss in scientific terms the extensive field of human activity covered by the extensive list of sciences and "near sciences" which directly involve mathematics.

(*e*) As a means of genuine enjoyment to a very large portion of secondary students. The fact is, that a considerable number of high school students voluntarily pursue mathematics with genuine enjoyment as the sole dominating motive. In *School and Society*, (January 29, 1916) Professor Millikan quotes Principal F. W. Johnson as asserting that the student vote on the question, "which had been very much enjoyed," ran: History, sixty-seven per cent; science, sixty-six per cent; French, sixty-three per cent; handwork, fifty-six per cent; mathematics, forty-nine per cent; German, forty-seven per cent; Latin, forty-five per cent; English, forty-three per cent. It will be noted that the subjects which rank higher in the table than mathematics are pure electives, whereas one year of mathematics is required of all students.

These results suggested to your committee the educational value of studying the reaction of secondary school students to the various subjects of their daily program. With that end in

view, the principals of three schools were asked to submit a questionnaire to the students, in which each one was asked to indicate the subjects he "enjoyed very much," those which he "enjoyed a little," and those "enjoyed not at all." The results are submitted in the following tables:

UNIVERSITY HIGH SCHOOL.

Table I.

Statement of Students as to Degree of Enjoyment Received from their Studies.

Subject.	Total.	(1) Very Much.	(2) A Little.	(3) Not at All.	(1) & (2)
History	149	100	47	2	147
		67.1%	31.6%	1.3%	98.7%
French	149	94	51	4	145
		63.1%	34.2%	2.7%	97.3%
General science	83	52	28	3	80
		62.6%	33.8%	3.6%	96.4%
Other sciences	151	103	41	7	144
		68.2%	27.2%	4.6%	95.4%
Popular arts	165	94	60	11	154
		56.9%	36.4%	6.7%	93.3%
German	146	69	65	12	134
		47.3%	44.5%	8.2%	91.8%
Mathematics	318	158	130	30	288
		49.7%	40.9%	9. %	90.6%
English	372	162	173	37	335
		43.6%	46.5%	9.9%	90.1%
Latin	233	106	99	28	215
		45.5%	42.5%	12.0%	88.0%
Music	49	26	16	8	41
		51.0%	32.7%	16.2%	83.7%

HYDE PARK HIGH SCHOOL.

Table II.

Subject.	Total.	Very Greatly	A Little	Not at All	
English	1416	890	471	55	1361
		62.8%	33.2%	4.0%	96.0%
Mathematics	955	492	348	115	840
		51.5%	40.2%	8.3%	91.7%
Latin	660	268	255	137	523
		40.6%	38.7%	20.7%	79.3%
German	322	169	121	32	290
		52.2%	37.6%	10.2%	89.8%
French	295	179	95	21	274
		60.7%	32.3%	7.0%	93.0%
History	504	265	197	42	462
		52.6%	39.1%	8.3%	91.7%
Physics	134	67	51	16	118
		50.0%	38.2%	11.8%	88.2%
Chemistry	109	64	42	3	106
		58.7%	38.5%	2.8%	97.2%
Botany	147	100	41	6	141
		68.0%	27.9%	4.1%	95.9%
Zoology	104	49	40	15	89
		47.1%	38.4%	14.5%	85.5%
Physiology	412	294	94	24	388
		71.3%	22.8%	5.9%	94.1%
Physiography	153	92	52	9	144
		60.1%	33.9%	6.0%	94.0%

OAK PARK AND RIVER FOREST HIGH SCHOOL.

Table III.

Statement of Students as to Degree of Enjoyment Received from their Studies.

Subject.	Total.	(1) Very Greatly	(2) A Little	(3) Not at All	(1) & (2)
Manual training	349	278	69	2	347
		79.6%	16.8%	3.6%	96.4%
General science	444	274	153	17	427
		61.7%	34.4%	3.9%	96.1%
Music	48	34	12	2	46
		70.7%	25.0%	4.3%	95.7%
Drawing	165	121	37	7	158
		73.3%	22.4%	4.3%	95.7%
History	460	265	173	22	438
		57.6%	37.6%	4.8%	95.2%
French	114	71	37	6	108
		62.2%	32.4%	5.4%	94.6%
English	1024	584	380	60	964
		56.0%	37.1%	6.9%	93.1%
German	234	117	96	21	213
		50.0%	41.0%	9.0%	91.0%
Mathematics	745	341	320	84	641
		45.7%	42.9%	11.4%	88.6%
Latin	483	186	230	67	416
		38.5%	47.6%	13.9%	86.1%

These tables are valuable for comparison of student reaction to subjects of their daily program. The large and vigorous Mathematics Club at Hyde Park High School supports the evidence. At present, student opinion is decisively in favor of organizing two additional Mathematics Clubs, indicating that mathematics is decidedly a promising field for "genuine enjoyment."

(*f*) Finally, and most important of all, mathematics is so well organized that it constitutes desirable subject matter for training in proper habits of study. Theoretically, every subject in the curriculum ought to contribute to this end. Practically, most of the subjects are, as yet, not sufficiently organized to attain this desired result. In fact, the other subjects gain in scientific character to the extent that they become mathematical. Psychologists insist that all thinking consists of problem solving. The formula as Thorndyke gives it is: (1) A clear statement of the goal aimed at; (2) the selection of enough and representative individual facts; (3) their arrangement in such a way as to make the general idea or judgment to which they lead obvious; (4) the verification of the conclusion by an appeal to known facts; and (5) its reinforcement and clarification by exercises in applying it to new individual facts. Success depends upon a proper method of attack. The mechanics of proper training in methods of study are most easily taught in a well-organized subject. This characteristic is the direct cause of the fallacy held by

many school executives that mathematics is most easily taught and, hence the direct cause of the "farming out" policy with consequentially poor results. The well-prepared teacher succeeds in "cultivating this scientific attitude," the proper tool for "getting into and under things."

4. There will be no great differentiation in the importance of mathematics as applied to secondary school girls and boys. The subject, except for the specific vocational and professional needs enumerated, functions equally in the lives of girls and boys. A greater number of girls will probably enter the specific fields listed. An even greater number will be sympathetic companions of husbands in these fields, or intelligent teachers of sons who are attempting to find their paths into them. Culture at least includes intelligent appreciation of positive human experience, and that experience has been shown to have infinite interrelations with quantitative thinking and expression.

5. The preceding paragraphs have not specifically referred to the much-debated disciplinary value of mathematics. Unless it can be shown that the leaders in the extensive list of human activities which include mathematics as a prerequisite are not able to determine what constitutes adequate preparation in their own fields, it must be granted that mathematics meets a considerable social need on the basis of utility, independent of any disciplinary value. The immediate problem of the teacher of secondary school mathematics appears to be the scrutinizing of his materials and methods so as to meet efficiently these needs without being concerned about disciplinary values. However, we are not ready to assume without further objective evidence that mathematics does not possess disciplinary values. As Professor Moore[2] points out, "It is absurd to contend that experiments based on the making of certain letters or guessing the sizes of pieces of paper will enable one to draw valid conclusions with regard to the training afforded by the study of mathematics." Indeed, it appears that the statistical manipulation of some of these experiments is questioned by experts. Although the geniuses of psychology are not agreed, the thinking public is as firmly convinced as ever of the high educational value of mathematics as is shown by Professor Hancock's[3] study. In this study, ninety out of a total of ninety-nine of the most prominent physicians, clergymen, lawyers and business men of the country

[2]See *American Mathematical Monthly*, February, 1916.
[3]See *School and Society*, June 19, 1915.

advocated a high school in which mathematics is a required subject; in a similar group of Cincinnati residents, ninety-six out of a total of 105 did the same thing. These replies are probably based on a deep conviction of disciplinary value rather than on utilitarian values. The burden of proof clearly rests upon those who deny the disciplinary value of mathematics without presenting reliable, objective, experimental evidence to support their radical opinions.

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The University of Chicago High School.
F. A. KAHLER,
New Trier Township High School.
O. M. MILLER,
Hyde Park High School.

THE CADDO OIL AND GAS FIELD.

GREAT PETROLEUM FIELD OF THE GULF COASTAL PLAIN.

Natural gas has been known near Shreveport, La., for more than twenty-five years, but oil was discovered here only in 1914, when the first successful well was drilled in what is now known as the Caddo oil and gas field. This field is chiefly in Caddo Parish, in the northwest corner of Louisiana, but extends westward a short distance into Marion and Harrison Counties, Tex. In 1906, the production of the field was only 3,358 barrels, which is less than the reported initial daily production of some of the more recent wells. From this time, the output increased until 1913, when the maximum yearly production of 9,628,177 barrels was made. Including the production of 1914, the Caddo field has yielded over 38,000,000 barrels of oil and a large but unknown amount of gas. Although this field may have reached its maximum production, it will not be exhausted for many years.

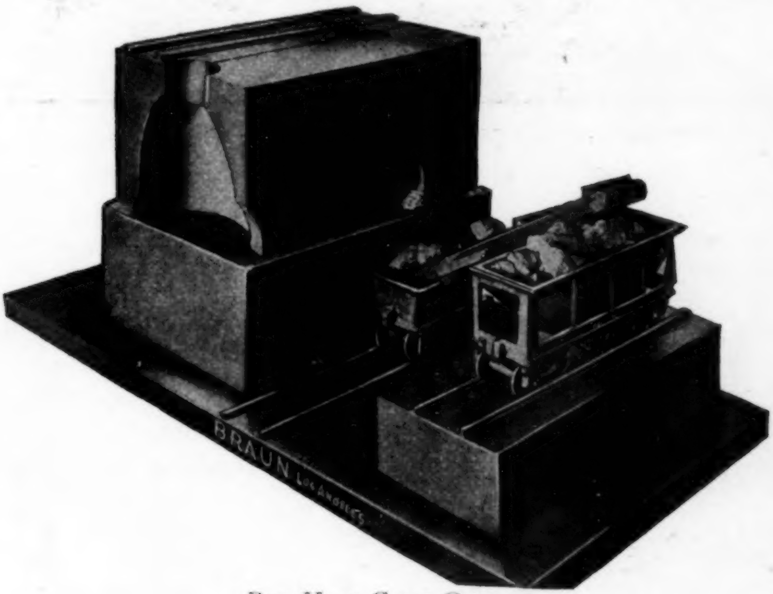
The result of an investigation by Geologist George C. Matson, recently published by the United States Geological Survey as *Bulletin* 619, shows that in this field oil and gas are found in three different formations and that oil has been found sporadically in a fourth. All the productive beds are in the Upper Cretaceous series. The shallow Nacatoch sand is a widespread gas-bearing sand and yields heavy oil in the northeastern part of the field; the Woodbine, the deepest productive sand, furnishes the high-grade oil of the Caddo field, and in many places contains sufficient gas to cause strong flows when the wells are first drilled.

The structure of the field, as shown by contour maps in the Survey report, consists of a series of anticlines and synclines extending in a northeasterly direction and crossed approximately at right angles by a northwesterly fold. The axes of the folds as outlined on the two key beds do not agree in position, a condition which is explained by the way in which the beds were folded. In this field, the rocks appear to be saturated, so that no extensive dry sands are encountered, and the distribution of the oil and gas is in accordance with the geologic structure. Oil is present in some of the shallow synclines as well as in the anticlines. The anticlinal theory of oil and gas accumulation is well illustrated locally in the northeastern part of the field, on what is called the Vivian anticline.

THE HOLLYWOOD CHEMISTRY MODELS.

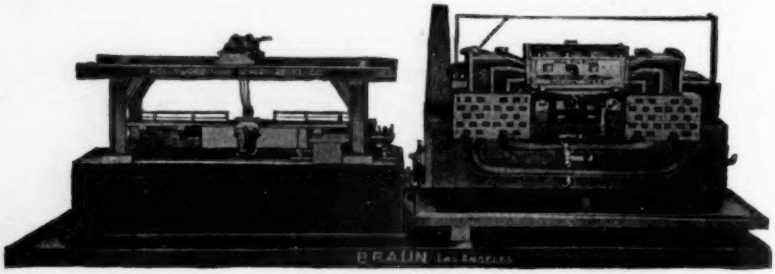
By C. W. Gray,
Hollywood High School, Los Angeles, Cal.

Chemistry has never appealed to the mass of the students as being a real, practical subject, one that they might find in their daily lives. As a remedy for this, we attempt to show the student the applications of chemistry in his daily life and in the industrial world. His experiences are as yet too limited and his knowledge of chemistry is not sufficient for him to appreciate or understand many of the applications in his daily life. The commercial applications are often presented in such a technical manner that it kills the very object of their use. More often they are presented in such a vague manner as only to confuse the student and destroy their usefulness. For this reason, many chemistry teachers have felt that the industrial applications were better omitted. Yet, when properly presented, industrial chemistry offers the largest field for applications that will make the chemistry of the classroom real and tangible, and show its practical value. The modern student must see where a subject has a practical commercial value before he is really and thoroughly interested.



Bee Hive Coke Oven.
Model can be dissected. One oven is cut through.

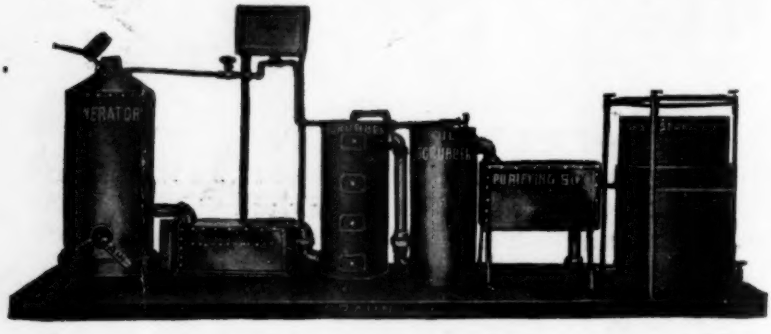
The large part of what a student really learns in science is obtained from his actually seeing a thing or phenomenon. It was for this reason that laboratory work is introduced into chemistry. It gives the student an opportunity to see and handle the various chemicals and observe their action on one another. More illustrations are being used in our text books, and teachers often



TILTING OPEN-HEARTH STEEL PLANT DISSECTED.

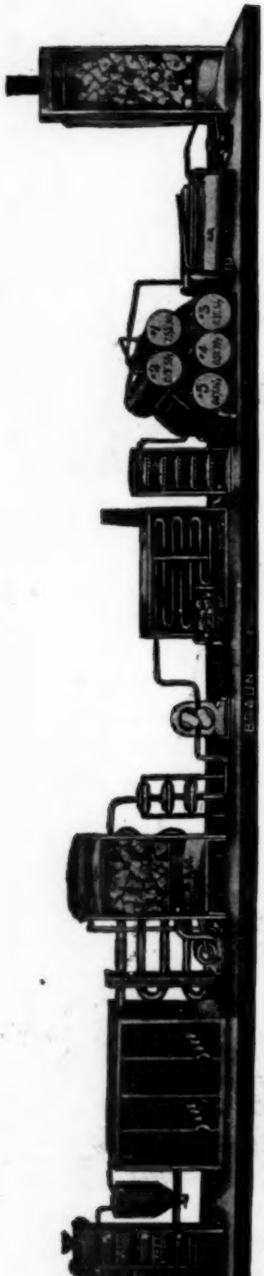
Air and gas pipes are placed in front of the regenerative chambers instead of the rear so as to show the entire operation in one view. Shows the construction of the regenerative chambers, the valves that control the air and gas, etc. Shows hearth dissected and the loader charging the furnace.

find that all a student has obtained from an assignment is what he has learned from the illustrations given in that lesson. The use of the lantern slide and opaque projector is a big help in the attempt to visualize chemistry, but these have not accomplished what it was hoped they would. Many students are not able to understand the drawings of industrial processes. The photo-



OIL GAS PLANT. WORKING MODEL.

An actual working model of an oil gas plant, modeled after a California Oil gas plant but not to a scale. Compressor and meter omitted. Model shows generator, washer, one of four scrubbers, oil scrubber (for removing naphthalene), purifying box, and gas storage tank. In operation illiminating gas is used to heat the generator instead of oil.



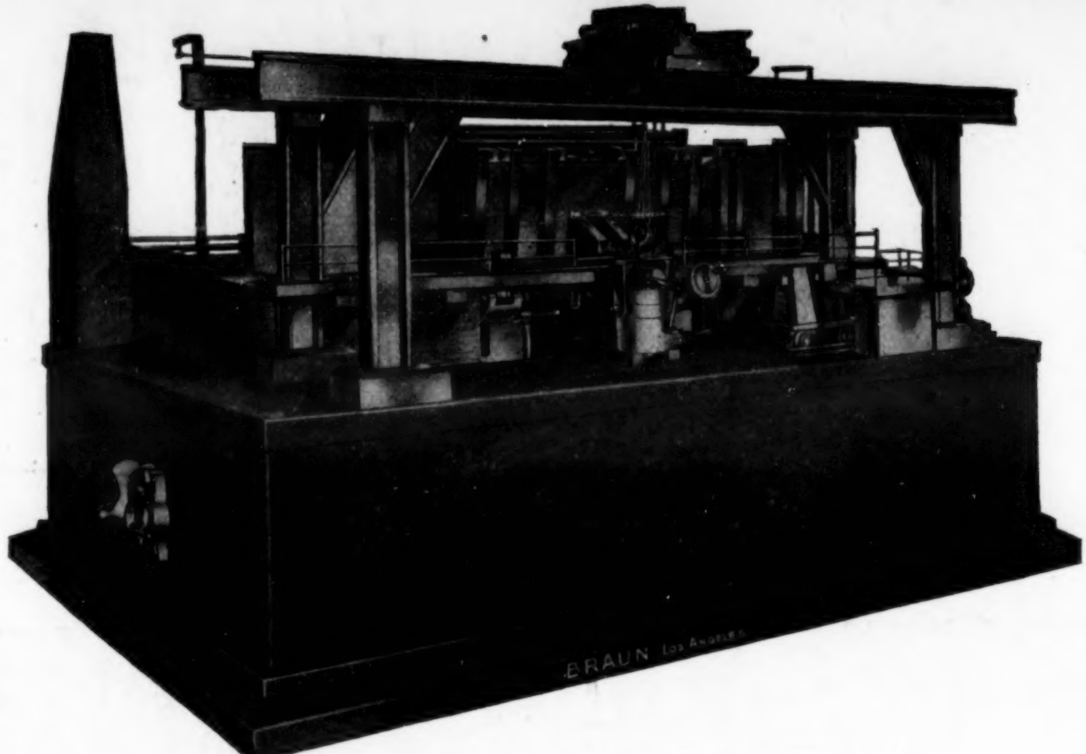
SULPHURIC ACID CONTACT PROCESS.

Modeled after a large modern plant where fuming sulphuric acid is made. Shows pyrites burner and the operation of the worm feed and rabble blades. Shows the dust catcher, dust chamber (¼ size), cooler, washer, filter, compressor (working model), preheater, converting tanks (one shown in cross-section), and the vertical tower.

graphs show only parts of the process, and the student's experience and imagination are not sufficient to connect them and get a proper perspective of the whole. Photographs showing interior view of apparatus and their operation are of course impossible. Moving pictures are an improvement on the lantern slides, but they are as yet expensive and limited. They do not give the proper perspective of an industrial process as a whole. They do not show the operation of the plant. True, the student sees belts and shafts in motion, but he does not see what is inside, let us say, of a big tank, and its operation.

As a remedy for these faults, many teachers that are fortunate enough to be in localities where they can visit industrial plants with their classes do so. What is the result? There are seldom enough guides and usually so much noise that the students can not hear. They are conducted from one building to another, not in a logical order, but by the most convenient route. The student has little or no opportunity to observe what the big tanks contain or the operation going on in them. He sees the plant piecemeal, and has no good view of the plant as a whole.

In order to remedy as many of these defects as possible, the writer designed and built the Hollywood chemistry models. The success of these models exceeded all expectations.



TILTING OPEN-HEARTH STEEL PLANT. GENERAL VIEW.

Shows hearth, tilting arrangement, butter-fly valve control, crane, ladle, and ingot train.

This model is built to a scale of ¼" to 1'. It is modeled after a large eastern furnace that has been recently built. All operations in the manufacture of open-hearth steel can be shown, from charging of furnace by the charging machine to the tilting of the hearth and conveying of the ladle of steel to casting pit where it is poured into the ingot moulds. The Model can be dissected to show the construction and operations of the various parts. By pushing a lever the valves are changed reversing the flow of gas, air, and the products of combustion.

The models enable the student to see and observe the operation of industrial plants not found in his locality. They are even better than having the plant located in his home town. They can be brought into the lecture room and thoroughly examined in a way not possible at the plant. In the models, each step of the process is placed in its logical order from left to right. The entire process can be seen at once, and its operation as a whole explained. Then it can be dissected and the operation of each part explained in detail. Lantern slides or moving pictures can now be used to give the student a proper idea of the size and working conditions. This can be followed by a special report by a student on the history, uses, etc., of the substance being studied.

Somebody has said that industrial chemistry is not of interest to girls. They are not interested when taught in the old way, for they have not had the boys' experience with machinery nor their opportunities of watching industrial operations. They are not familiar with cross-sectional drawings and most boys are. We are hardly fair to the girls as we attempt to explain things based on the boys' experience. The girl, lacking this experience, has nothing for her imagination to build upon. With the use of the Hollywood chemistry models, this is all changed. If one view does not give her a clear idea of it, she can turn it around and inspect it from all viewpoints. All her imagination has to do is to enlarge it as the models are built to a scale.

Most chemistry teachers take their classes to at least one or two local plants. Now put a model of one of them before the students and carefully explain it. They get an idea of the shape of each part, what it contains, and how it works. Now visit the plant and note the difference between this and last year's visit. They recognize each part, know its operation, and its relation to the plant as a whole. Now nothing is left to the imagination. The model leaves only the enlarging, and the visit to the plant does that.

The models reduce the time necessary in teaching the industrial applications, leaving more time to devote to the study of the more theoretical parts of the text. In this manner, industrial chemistry teaches itself with almost no effort on the part of the student or teacher, and teaches it so clearly as to remain firmly fixed in the student's mind.

Those interested in the use of models in teaching chemistry can obtain of The Braun Corporation of Los Angeles their descriptive bulletin, *E 105*.

WHAT IS MOST WORTH WHILE IN ZOOLOGY FOR PUPILS IN SECONDARY SCHOOLS?[1]

By Jerome Isenbarger,
Nicholas Senn High School, Chicago.

The subject as assigned to me is happily stated in that it mentions the pupil. Too often, I fear, we have neglected to take the needs, likes and dislikes of the pupil duly into consideration while shaping our courses of study. We have passed judgment on the basis of what we thought the college required of us or what we, from a perspective gained from years of study in college and university, have found to be the lines of least resistance.

The claims that have generally been made for scientific study are that it gives practical information, that it trains in accurate observation, that it inculcates habits of efficient and original thought, and that it fosters a permanent interest in scientific information and study.

In former years, the subjects of the curriculum were pretty definitely classified as either cultural subjects or practical subjects. The so-called humanities had their indubitable place among the former, while the sciences and vocational studies belonged to the latter. Educators are coming more and more to agree that a subject can be cultural and practical at the same time. The special culture furnished by science is not a whit less important than that given by the classics, literature and history. We must guard against the mere utilitarian views which would justify the place of zoology in the curriculum. We should not minimize the material achievements of this branch of science, but we should bear in mind that these are not of supreme importance.

In city life, the child has been taken away from a life in which he was largely his own nature teacher, and we have surrounded him with artificial conditions which tend to lead the child away from nature interest and ripen adult interests prematurely. Nature study should bring the child back to the nature from which he has sprung and, thus conceived, it should be a corner stone of education.

The question which is especially pertinent in this discussion is, how can zoology best serve the purposes of science in the education of the youth at high school age. By oral instruction and reading, a pupil may derive useful information, but information is not education, it is not intellectual power, without which all

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1 Read at the University of Chicago Secondary School Conference, April 14, 1916.

education is distinctly defective. True education comes mainly through the inductive method, the method of the laboratory. Results must not be measured by facts stored up but by power developed.

In considering the practical aspects of zoology teaching, I desire to distinguish between the practical and the vocational. The study of zoology in the secondary schools should be a study of life—of animal life. Man, representing the highest type of animal life, should be considered constantly in his relation to other forms. From the lowest forms, parasitic in the case of certain protozoa, to the highest which may be useful or injurious, there is a constant relation which should be kept prominently before the pupil. "Information is useful to an individual only when it has in it elements that belong to the life situations in which he is placed, and that are significant to some real present or future need that is apparent to him. Information, to be useful to an individual, must be acquired in such a way that when significant and needed it can be recalled and used." These tests of usefulness should be applied to information in zoology. Information which meets these requirements is practical.

In the Senn High School, the pupils in the zoology classes study the life history of the house fly and of the mosquito, using living material in all stages of development in the laboratory. After this, each pupil constructs a sanitary map of his neighborhood. On this map are located places where conditions are such that flies and mosquitoes may breed; grocery stores, bakeshops, restaurants and candy stores where food is left exposed to flies and dust; also places where food is for sale and special precautions are used to keep the food clean. Houses in which there have recently been cases of contagious or infectious disease are located. From a consideration of all available data, the pupil is asked to form a conclusion as to the relation between the sanitary conditions in the neighborhood and the health of the community. If conditions are not as they should be, the pupil suggests means for improvement. Civic zoology of this sort brings every pupil face to face with the fact that he is a vital part of the community and that the welfare of the community depends upon the individuals who compose it. Such work is thoroughly practical.

Animal husbandry, on the other hand, while giving information which is important, is not practical when considered in relation to the needs of city students in general zoology. We need to distinguish between the practical knowledge which is useful to

the mass of pupils in general and the strictly vocational which may apply to only a few in any one class.

There is a tendency to over-specialization. Pupils in zoology in secondary schools need, first of all, a good foundation in the principles of general zoology. Agriculture, when given in the high school, should follow as a separate course the work in zoology.

While urging that some of the frills be left out of the year of general zoology, I do not mean to put my stamp of approval upon what may be considered to be the old-line zoology teaching which has been too much in vogue in the high schools. The kind of teaching as frequently practiced has no sound pedagogical basis. Zoology too often begins with classification, nomenclature, dissection, when it should begin with the general. The systematic method which takes up in detail the study of a group or groups in a most careful manner, from the taxonomic standpoint, brings the pupil in contact with the thing studied and trains in powers of analysis and discrimination, but it gives the pupil a wrong notion with regard to the importance of certain structural parts and of isolated animal groups and fails to inculcate general biological notions.

The chief purpose of the laboratory is defeated if pupils are not held responsible for careful and accurate work. The study of a limited number of types should be followed rather than a superficial study of a large number of forms. Quality should be emphasized rather than ground covered. Systematic work and minute anatomy are out of place in high school zoology. There should be only enough of internal morphology for a sufficient understanding of the physiology. "The point of view becomes that of the disinterested spectator rather than of the lover of and participator in, nature. It makes nature seem dead and far off, when it should be near and at every point full of life."—Partridge.

The living animal should be studied both in the field and in the laboratory. External morphology, life histories, habits and economic studies are of far greater interest and value to the pupil than minute dissection. A series of types can be selected from local forms so that living forms may be used in succession.

The life history work constitutes an important part of the laboratory practice in the Senn High School. Last fall cecropia and polyphemus caterpillars were brought into the laboratory, fed on willow leaves and allowed to spin their cocoons. The

pupils watched the various processes and at this time they are seeing the adult moths emerge from the cocoons. Salamander eggs are brought into the laboratory and the pupils watch the embryos develop through all stages to adult form. Other life histories which have been used are those of the fly, mosquito, dragon fly, scavenger beetle and snail.

There is no phase of the zoology work which is more important and none which should be handled more tactfully, yet thoroughly, than that dealing with the processes of reproduction. I am fully convinced that mixed classes can be taught the truth concerning these processes without a word of objection from any source. One pupil has stated it in this manner: "There should be, by all means, a study of sex—not, however, so that the pupils will be conscious of any emphasis, but it should be studied as an important phase of existence. A careful, thoughtful study of the sex gives one a broad outlook upon life and an understanding of things as they are." Material that can be used in the laboratory in this connection are pigeons, eggs in the process of incubation under a hen, guinea pigs, rabbits and white mice. Throughout the year, the work on reproduction with the various types of lower animals may be so planned as to lead up to this work with the living higher animals.

The laboratory study of an animal should begin with the living form. The pupils are, by nature, interested in living things, and living animals in abundance should be kept in the laboratory because of the interest that the pupils take in their presence and in their care. Bees, mussels, snails, crayfish, fish, tadpoles, frogs, toads, salamanders, turtles, snakes, ringdoves and canary birds can all be kept and made comfortable in the laboratory.

Many teachers have dismissed the idea of doing field work in city schools with the excuse that it is impracticable. This excuse may hold in some cities, but it is not well taken in Chicago. It is not an easy matter to conduct effective field work with large classes, and here again we are inclined to a choice of the easier way. The phase of field work which has led to most satisfactory results is that which comes in the study of birds during the spring migration. The knowledge and inspiration which a pupil gets by the study in the laboratory of dried and dusty bird skins does not begin to compare with what the pupil gains when he goes afield with a glass and a color key. Various bird contests may be used, a bird club may be organized, but in any case a bird calendar must be kept during the spring migratory period. The teacher

should take frequent excursions with the classes, but much of the work, after it is fairly started, will be done by pupils working alone or in groups. In Senn High School, short trips are sometimes taken during the regular laboratory period, but more frequently they are taken in the morning before school, after school, or on Saturday morning.

Summing up, the study of the themes of heredity, variation, recapitulation, natural and artificial selection, the struggle for existence, developmental histories and other phases of general zoology should be illustrated and enriched by a study of the living animal wherever possible, and the nature of the course

and choice of material should, in every case, be governed by the needs and inclinations of the pupil.

In order to secure data which might lead to some conclusions as to where the high schools are placing most emphasis and as to what the colleges are expecting of the high schools in zoology, I sent letters to various larger high schools outside of Chicago, requesting lists of questions which have been used in term examinations, and to a number of the larger colleges and universities requesting questions which have been used in their college entrance examinations. I also secured a number of sets of the questions prepared by the College Entrance Board.

These questions, in each case, were analyzed and classified according to subjects. The accompanying chart shows where emphasis is placed by the high schools and also where the colleges would like to have the emphasis placed. A study of the data fails to justify the oft-repeated accusation that the college dominates the high school in the matter of requiring an undue proportion of internal morphology and taxonomy. In each case, the high schools are giving more than the colleges require. The high schools might enrich their courses with more of external morphology, life history, adaptations and evolution and still satisfy the requirements of the college.

The College Entrance Examination Board bases a third of its zoology questions on structure, a third on physiology, life history and classification, and a third on the relations of animals to human welfare.

EDUCATIONAL WORK FEATURE OF ELECTRICAL EXPOSITION—NEW YORK VOCATIONAL SCHOOLS TO HAVE EXTENSIVE EXHIBITS.

The Electrical Exposition of 1916, which will be held at Grand Central Palace, New York City, October 11th to 21st, will be of exceptional interest to educators and to those interested in vocational training schools. The Board of Education of New York City, has authorized for the Electrical Exposition what will amount to practically a complete demonstration of the work of the Vocational Schools of Greater New York. This will be an unusual opportunity to see under one roof working exhibits of practically all of the work of one of the country's greatest vocational school systems. The exhibits include house wiring for electricity, printing, plumbing, sign painting, draughting, machine shop work, wood working, sculpturing, drawing, cooking, art needle-work, garment designing, dressmaking, millinery, cabinet-making, and in fact all of the work taken up by the vocational schools for girls and boys, most of which is carried on by means of electricity.—*The Electrical Exposition News Bureau, New York City.*

CLASSROOM SAYINGS.

The following are from a physiology test:

The sternum is in the diaphragm.

The parts of the alimentary canal are the gullet, stomach, windpipe and gizzard.

The bones of the hand are the carples, metacarples and flyanges.

The following answer was given by a *freshman girl* in a *test* in physical geography:

Question: Define the dew-point.

Answer: Dew is moisture condensed by the cooling of the air. A point is a thing that has neither length, breadth nor thickness.

A mordant is something up-to-date.

Carbolic acid is very poisonous and should never be used alone, so caution is used with it.

Permeability is that which may be hammered out, and is the opposite of retentivity.

Morse invented the telegraph through fooling with a key.

A hydraulic elevator is something to find the density of water.

The amount of work required to move one ton, six inches, is the required amount.

A dyne is the amount of work done, acting for one second upon one centimeter, producing a momentum and change in velocity.

A calorie is that which is necessary to raise one gram of water through one degree centigrade without changing its temperature.

The unit of heat is the degree which is 1/3600 of a second.

A force acting upon the law of inertia and returning to standard center is called "centerfigal" force.

A dyne is that force which produces a change of one degree centigrade on one centimeter of water.

Dip of compass needle—when one dyne of force acts on magnetism.

What is Pasteurization?

1. Pasteurization is by pasturing animals in a certain place to prevent bacteria.
2. Pasteurization is subjecting a person to heat.

Quinine is secured from algæ.

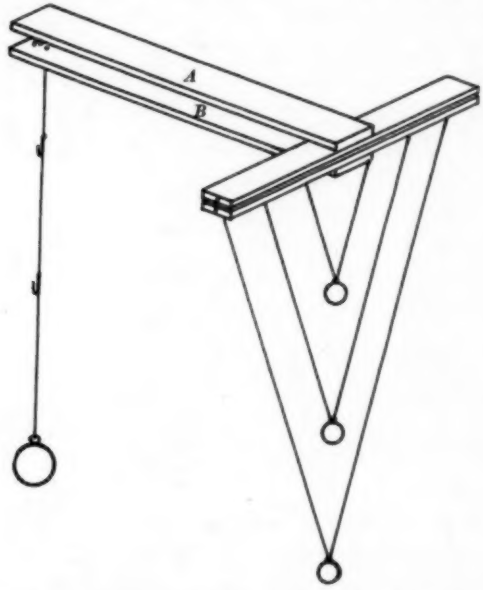
Jasimine is a form of silicon dioxide.

From report on preparation of iodine: Violent (violet) vapors were formed.

AN IMPROVED RESONANCE MODEL.

By Will C. Baker,
Queen's University, Kingston, Ont.

The following note describes a form of resonance model that has several advantages over the one usually employed.



A and B are two T-shaped frames of lath, the crosspieces being about 20 cm. long and the stems about 30 cm. These are held opposite one another, as shown, by three short cords at the ends of the crosspieces and at the end of the stems. The distance between the faces of the crosspieces is 3 or 4 mm. Three wooden balls (about 1 cm. in diameter) are bifilarly suspended, as shown, from the lower crosspiece, at distances of about 25, 50 and 75 cm. respectively. At the other end of the lower frame is hung, by a single cord, an iron ball (diameter about 5 cm.). In its lowest position the iron ball has the same period as that of the lowest wooden ball; but it may be lifted to either of two hooks—permanently attached to the cord—in which positions it swings with the free period of one or other of the upper wooden balls. The upper frame is firmly held in a laboratory stand so that the lower T is free to swing in a horizontal plane.

The demonstration is started by giving the iron ball an oscillation of 5° or 10° to and from the wooden balls. The bifilar sus-

pensions confine the motion of the lighter spheres to one plane so that their amplitudes are easily compared. The mass of the wooden balls is small so that they do not sensibly react on the motion of the driving sphere. The wooden ball that is in resonance with the iron one quickly works up to a large amplitude while the other two are *alternately started and stopped* by the impulses that arrive out of phase with their motion. The amplitudes of these balls vary within small limits but the limit is not too small to be seen by the entire class. It is, of course, as important for the pupil to see why the pendulums that are "out of tune" do not vibrate violently as it is for him to see why the one "in tune" does acquire its large amplitude. With apparatus of about the dimensions given, the action goes on sufficiently slowly for the class to follow. If the driving ball be lifted from one position to another, while one of the wooden balls is in violent motion, the setting up of the new regime is full of interest to a class.

METHOD FOR SHOWING TOTAL INTERNAL REFLECTION.

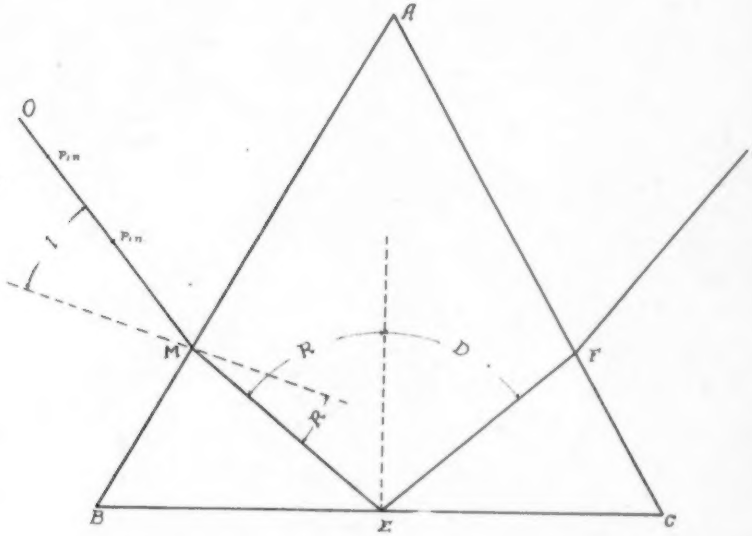
By A. Haven Smith.

The accompanying drawing illustrates a method we have used for demonstrating total internal reflection. It has proved useful in allowing the pupil to see for himself that light will not always pass through a transparent substance.

An equilateral prism of glass, 7.5 mm. on a side and .8 mm. thick, was placed on a sheet of paper. The triangle ABC was drawn to coincide with its edges. Two pins were placed in line. The student, while looking through the prism, drew a line, HF, which would apparently pass through the two pins. Removing the prisms and pins, the line OM was drawn. These two lines, OM and HF, marked the path of the ray of light before entering and after leaving the prism. The angle of incidence, I, was measured, and from this and the index of refraction, the angle of refraction, R, was computed. With this angle, the path of light to the point E was drawn. The points E and F were then connected and the complete path of the ray was known.

As a check on the work, we had the student erect a perpendicular at E and measure the angles R′ and D. These frequently checked to within half a degree. The maximum difference between the two angles reported was 2 degrees. Some of the stu-

dents had trouble in not being able to see both the pins in the line in which they had been placed. This was avoided in later classes by directing them to place one pin in position, and while looking through the prism adjust the other, until both pins could be seen in line.



AIR PRESSURE—HOW IT WAS DISCOVERED—STORY OF THE BAROMETER.

By Merton C. Leonard,
Dickinson High School, Jersey City, N. J.

Introduction.

There is something cultural and satisfying in learning how the great scientists of the past "thought it out," and what experiments they devised to prove or disprove old theories. It is stimulating to learn of their boldness in challenging the verdict of the age, and of their sublime faith that truth would ultimately triumph over error, prejudice and superstition.

Teachers who become stimulated to admire whole-souled *devotion to truth for the sake of truth* unconsciously become better companions for their pupils.

When a science teacher finds his work becoming monotonous or stale, let him but familiarize himself with the historical background of the science he teaches. This will give him a new

resource upon which he may draw, and thus wonderfully enrich all his teaching. In oral instruction, the story, well told, always finds a welcome. It adds one hundred per cent to the interest and value of the Torricellian experiment to tell the story, somewhat as given below, while the experiment itself is being made before the class.

This story, adapted (with extensive modifications and additions) from the account in Cook's *Religion and Chemistry* (now out of print) is offered here partly from the conviction that many teachers will find it of practical value in the classroom, and partly to preserve in print what is probably the best account of the work of Torricelli and Pascal on the subject of air pressure to be found in the English language.

The following accounts of air pump experiments were taken with some changes, from Cajori's *History of Physics*—a book that all teachers of science may often refer to with profit.

WEIGHT, PRESSURE AND EXPANSIBILITY OF THE AIR.

That air has weight may be proved by weighing a flask when full of air and again after exhausting the air. Galileo proved the same point, by weighing "a glass balloon filled with air under ordinary pressure and then with air under high pressure."

Atmospheric pressure is illustrated by the action of the common lift pump, by the great force required to separate the Magdeburg hemispheres, by the hissing sound which you hear as you begin to open a can of preserves, by the water remaining in the inverted tumbler that is capped by a piece of moist cardboard, and other experiences even more familiar to us.

About the middle of the seventeenth century, when the truth of atmospheric pressure was just dawning upon the human mind, Guericke—the inventor of the air pump—made for the first time many interesting experiments based on air pressure. From a tight wine cask filled with water, he attempted to remove the water without allowing air to get into the cask. By using the force of three strong men, he succeeded in drawing out most of the water, whereupon "a noise was heard as if the residual water within were boiling violently, and this continued until air had replaced the water which had been pumped out."

"The leaky wooden cask was then replaced by a copper globe, and water was drawn out as before. At first the piston moved easily, but later the strength of two men could hardly move it, when suddenly with a loud clap, and to the terror of all, the sphere collapsed."[1]

But perhaps Guericke's most famous experiment was the one with the large Magdeburg hemispheres performed at Regensburg in 1654 before the members of the Reichstag and Emperor Ferdinand III. The hemispheres had a diameter of nearly fifteen inches and, according to the calculations of the experimenter, a force of 2,686 pounds was needed to overcome the atmospheric pressure which held the hemispheres together. They were pulled apart by the combined strength of sixteen horses, four pairs being attached to each hemisphere. Undoubtedly, fewer horses would have sufficed. It is probable that the larger number was used more for dramatic effect than from necessity.[2]

Another experiment, illustrating the power of air pressure sometimes called "suction," is described as follows: A cylinder of a large pump had a rope attached to its piston which led over a pulley, and was divided into branches on which twenty or thirty men could pull. As soon as the cylinder was connected with an exhausted receiver, the piston was suddenly pushed down by the atmospheric pressure, and the men at the ropes were suddenly pulled forward.[3]

With air pumps of various types which Guericke invented, he was able to produce a vacuum with ease, and thus he could make many experiments to find out how things behave in an empty space. In this way it was learned that a clock cannot be heard when it strikes in a vacuum; that nothing will burn there; that a mouse shows signs of distress and lives but a few moments; "that a bird opens its bill wide, struggles for air, and dies; that fishes perish; that grapes can be preserved six months *in vacuo*."[3]

The Barometer—How It Was Discovered That It Is Atmospheric Pressure That Supports the Water in a Lift Pump and the Mercury in a Barometer.

The effects of air pressure are so numerous and so conspicuous that even the ancient Greeks sought a theory to explain such things as the action of a siphon, and of a pump; the fact that water is supported when a full inverted bottle is placed in a basin of water; or when a full tube, open below and closed above, is similarly placed; and the running out of the water, in this instance, when the top is opened. These ancient philosophers noticed also that space was always filled with some material sub-

[1]Adapted from Cajori's *History of Physics*.
[2]*Physics*, by Mann & Twiss. Cut, opposite page 125.
[3]Cajori's *History of Physics*, pages 68, 70.

stance, and that the moment a solid body was removed, air or water always rushed in to fill the empty space. Hence they concluded that it was a universal law of nature that space could not exist unoccupied by matter. This simple theory they expressed in the phrase—*Nature abhors a vacuum.* Making use of this theory, they explained the rise of water in a lift pump by declaring that, as from the nature of things a vacuum could not exist, the water necessarily filled the space deserted by the piston.

This interesting theory, though imperfect and wrong because it introduced the idea of an emotion, horror, to account for physical facts, yet served the purpose of natural philosophy for about two thousand years, and doubtless it would have served longer had it not been discovered that *under certain conditions nature does not abhor a vacuum.*

Near the middle of the seventeenth century, some engineers were employed by the Duke of Tuscany to sink a well in the neighborhood of Florence to an unusual depth. They finished their task, but on adjusting the pump they found to their surprise that it would not work. In spite of their efforts, the water would rise only about thirty-three feet, and by no ingenuity or skill could they raise it an inch higher. Here then, in the cylinder of the pump, between the top of the water column and the piston, was a *vacuum* which nature refused to push the water into although plenty of water was right at hand. Thenceforth science had a new fact to deal with, and the old theory could no longer stand. The baffled engineers, more disgusted with nature than nature was with the vacuum in their pump, applied to Galileo, then an old man, living in his villa, on the brow of a hill near by. He could not aid them, but he is said to have replied, half in jest, and half in earnest, that nature did not abhor a vacuum above ten meters. Had this incident occurred earlier in his career, it is likely that Galileo would have arrived at the new truth that was just about to dawn on the scientific world, but now the vigor of his manhood was spent; he had done his work and was peacefully resting from his life's labor, and calmly awaiting the close.

But the key which the incident had furnished was not lost. It passed into able hands, and it was the fortune of Torricelli, Galileo's best pupil, to unlock the secret. This young Italian philosopher, whose clear intellect had been trained in the mechanical philosophy of his great master, saw at once that a column

of water thirty-three feet high, and no higher, could not be sustained in a cylindrical tube by a mere phrase or emotion. This effect, he reasoned, must be the result of some mechanical force equivalent to the weight of the mass of water sustained. It was not difficult to prove the correctness of this reasoning, for it was evident that if a column of *water* was sustained at the height of thirty-three feet in the suction pipe of a pump by a constant force, the same force would sustain a column of a ***heavier liquid*** only to a proportionally less height. If he should use a liquid twice as heavy as water, the column would be only one-half as high as the water column; if three times as heavy, then only one-third as high, etc. So Torricelli tried mercury—a liquid thirteen and one-half times as heavy as water—and the result was as he had anticipated. The force—whatever it was—which raised the column of water thirty-three feet could raise a column of mercury only to the height of about thirty inches, which is 13.5 times less than thirty-three feet. Torricelli did not, however, make this experiment with a pump, but with an apparatus of his own devising, much simpler and equally effective.

He took a long glass tube, open at one end, filled it with mercury and, having closed the opening with his thumb, inverted the tube, and plunged the open end into a basin of mercury; on removing his thumb, the mercury, instead of remaining in the tube, and thus satisfying nature's abhorrence of a vacuum, fell, as he expected, and after a few oscillations, came to rest at a height of about thirty inches above the level of the mercury in the basin. The correctness of his induction having been thus verified, Torricelli at once concluded that it must be the pressure of the air which sustained both the water in the pump and the mercury in the tube. This experiment was made in Florence in 1643, and when the news of it spread among the scientific men of Europe, it excited a great sensation, but, as might naturally have been expected, the old horror-of-a-vacuum theory was not easily displaced, and Torricelli did not live to see his opinion generally received. It was left to the celebrated Blaise Pascal—a distinguished physicist of France—to convince the world that Torricelli was right, and this he did by one of those master strokes of genius which at once silence controversy.

"If," said Pascal, "it be really the weight of the atmosphere under which we live that supports the column of mercury in Torricelli's tube, then, at a higher altitude, the column ought to be shorter, for, by transporting the tube upwards, we leave above

it less air that can exert pressure upon it. Accordingly, he carried the tube to the top of a church steeple in Paris, and observed that the mercury fell slightly, but not being satisfied with this indecisive result, he wrote to his brother-in-law, M. Perrier, who lived near the high mountain of Puy de Dome in Auvergne, asking him to make the experiment there where the result would be more decisive. "You see," he writes, "that if it happens that the height of the mercury at the top of the hill be less than at the bottom (which I have many reasons to believe, though all those who have thought about it are of a different opinion), it will follow that the weight and pressure of the air are the sole cause of this suspension, and not the horror of a vacuum; since it is very certain that there is more air to weigh on it at the bottom than at the top; while we cannot say that nature abhors a vacuum at the foot of a mountain more than on its summit." M. Perrier, Pascal's correspondent, made the observation as requested, and found a difference of three inches of mercury, "which," he says, "ravished us with admiration and astonishment."

In passing, we should note that this new truth was arrived at not by *discussion*, but by *experiment*. Guericke, the scientist who made so many experiments with air pumps, especially realized the futility of *talking*, and the value of *doing*, for, he said, "Oratory, elegance of words, or skill in disputation avails nothing in the field of natural science." In an age when it was regarded as a desecration to dissent from the teachings of Aristotle, only men of exceptional talent, originality and moral courage dared to go directly to nature for answers to the great philosophical questions of the day. Hence we are indebted to these great men not less for their *fearlessness* than for the usefulness of the truths they discovered, and the help they gave as pioneers in bringing into fashion the experimental method of studying natural science.

GENERAL SCIENCE.

SCHOOL SCIENCE AND MATHEMATICS:

For some time past I have been very much interested in the introduction of general or elementary science courses into our schools in South Dakota. Being one to early introduce such a course, it was my province to speak at the last session of our educational association on this subject. In making my search for the best criticisms, I had some correspondence with many of the textbook writers and companies, as well as with educators who endorsed or refused to endorse the course. I am glad to read Dr. Hessler's paper in this recent issue. He and Professor Eikenberry and Principal Rynearson are especially able to write with authority on this subject.

I have, however, a modern statement from Professor Kuykendall, late of the high school department of the Washington State Normal. The day before Professor Kuykendall died, he sent this enclosed statement to Dr. Nash, President of the Normal and my personal friend, who in turn sent it to me. If you find it worthy, will you not publish this statement from one who gave his best years to educational pursuits?

Very truly yours,

T. L. JONES,
Superintendent.

ELEMENTARY SCIENCE.

Every subject in the high school curriculum today has had a struggle for its introduction, and some of them have caused many controversies for their continuation.

A quarter of a century ago, science was struggling for acknowledgment in the curricula of the high schools of the country. The individual sciences, viz., botany, physics, chemistry, biology, physiology, geology, and zoology have passed through some such experience.

General science may be a misleading term. Possibly *elementary science* or *first-year science* might be more definite in meaning. *General science* has been held to mean a summary of the good things of all the sciences, but to follow, rather than precede, the study of the various sciences.

As now applied, *elementary science* is a study of the elementary principles of the various sciences, the aim being to familiarize the student with the basic principles of these sciences, thereby awakening his interest along lines from which he might select

some phase of science and make a careful, systematic study of it.

Some hold that a book on ***elementary science*** should have as a basis some one science, about which the material from the other sciences may be grouped. Such is the construction of Snyder's book which has for its basis physical geography. Other authors disregard this idea and balance the subject matter very well with material from all the sciences. These are generally considered by the specialists as being very unscientific. It is also true that the scientist has his specialty as his chief topic of attention even when he tries to be general.

All present-day enterprises are based on some scientific basis. Every child should have an opportunity to know these principles. Many pupils do not remain until the end of the high school course, nor can all students who remain in school for the entire high school course take all the sciences, therefore it is highly advisable to present every student of the high school an opportunity to master the most useful principles that affect everyday life, present and future. A glance at the table of contents shows to what extent this is carried. One book even takes up the selection of economic menus of dietary standard, home and school lighting, labor-saving devices, sanitation in the school, the home, and the community, and many other useful projects.

It seems that with the large number of books now on the market, one should select the material best suited for his individual pupils. No one book has a corner on all the best material. Much good, useful information should be presented in one year of time—about two hundred forty hours.

The great difficulty to administrative officers in our schools is the lack of properly qualified teachers to teach the subject.

PROFESSOR KUYKENDALL,

Late head of the High School Department, Washington State Normal, Bellingham, Wash.

A BIG SPRING.

The state of Florida has its full share of large and beautiful springs. Many of them form good-sized streams from the beginning, and some are navigable.

The largest spring in the state, and one of the largest and probably the best known in the United States, is Silver Spring, which is located six miles east of Ocala. This spring forms the principal source of Oklawaha River, a tributary of the St. Johns, and steamboats traversing the river enter the spring basin, which has an area of several acres. The water is from nine to thirty feet deep and wonderfully clear, appearing absolutely colorless.

PROBLEM DEPARTMENT.

By J. O. Hassler,
Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Algebra.

471. *Proposed by H. Perkins, Battleford (Saskatchewan) High School.*

If
$$x^{1/4}+y^{1/4}+z^{1/4}=0 \tag{1}$$
Prove that
$$[x^2+y^2+z^2-2(yz+zx+xy)]^2=128xyz(x+y+z) \tag{2}$$

I. *Solution by R. M. Mathews, Riverside, California.*

Square (1) and
$$x^{1/2}+y^{1/2}+z^{1/2}=-2(y^{1/4}z^{1/4}+z^{1/4}x^{1/4}+x^{1/4}y^{1/4}) \tag{3}$$
Square (3) and simplify and
$$x+y+z-2(y^{1/2}z^{1/2}+z^{1/2}x^{1/2}+x^{1/2}y^{1/2})=8x^{1/4}y^{1/4}z^{1/4}(x^{1/4}+y^{1/4}+z^{1/4})$$
and the right member of this is 0 by (1). So
$$x+y+z=2(y^{1/2}z^{1/2}+z^{1/2}x^{1/2}+x^{1/2}y^{1/2}) \tag{4}$$
Square (4) and simplify
$$x^2+y^2+z^2-2(yz+zx+xy)=8x^{1/2}y^{1/2}z^{1/2}(x^{1/2}+y^{1/2}+z^{1/2})$$
This squared gives
$$[x^2+y^2+z^2-2(yz+zx+xy)]^2=$$
$$64xyz[x+y+z+2(y^{1/2}z^{1/2}+z^{1/2}x^{1/2}+x^{1/2}y^{1/2})],$$
and by help of (4) the right member of this reduces to
$$=128xyz(x+y+z).$$

II. *Solution by C. A. Nickle, State College, Pa.*
$$\sqrt[4]{x}+\sqrt[4]{y}+\sqrt[4]{z}=0.$$
Transposing and squaring,
$$\sqrt{x}=\sqrt{y}+2\sqrt[4]{yz}+\sqrt{z},$$
Transposing again and squaring,
$$x+y+z-2\sqrt{xy}-2\sqrt{xz}+2\sqrt{yz}=4\sqrt{yz},$$
or
$$x+y+z=2\sqrt{xy}+2\sqrt{xz}+2\sqrt{yz} \tag{A}$$
Squaring,
$$x^2+y^2+z^2+2xy+2xz+2yz=4xy+4xz+4yz+8\sqrt{x^2yz}+8\sqrt{xy^2z}+8\sqrt{xyz^2},$$
or
$$x^2+y^2+z^2-2(xy+xz+yz)=8\sqrt{xyz}(\sqrt{x}+\sqrt{y}+\sqrt{z}),$$
and
$$[x^2+y^2+z^2-2(xy+xz+yz)]^2=64xyz(x+y+z+2\sqrt{xy}+2\sqrt{xz}+2\sqrt{yz}).$$
Substituting for $(2\sqrt{xy}+2\sqrt{xz}+2\sqrt{yz})$ its value from (A),

$$[x^2+y^2+z^2-2(xy+xz+yz)]^2 = 128xyz(x+y+z).$$

472. *Proposed by Elmer Schuyler, Brooklyn.*

If n is even, show that $n(n^2+20)$ is divisible by 48.

1. *Solution by Louis Clark, Lewiston, Vermont, and M. Helen Kelley, Wilmette, Ill.*

To prove that $n(n^2+20)$, n an even positive integer, is divisible by 48, it is necessary and sufficient to show that it is divisible by 16 and by 3.

Since n is even we may put $n = 2m$; then the given expression becomes $8m(m^2+5)$. If m is even, the first part, $8m$, is evidently divisible by 16; if m is odd, evidently $8(m^2+5)$ is divisible by 16. Hence, the expression is divisible by 16. Furthermore, if m is a multiple of 3, evidently $8m(m^2+5)$ is divisible by 3. If m is not a multiple of 3, it is of the form $3r\pm1$, (r an integer), so that m^2+5 becomes $9r^2\pm6r+6$, which is divisible by 3. The given expression is, therefore, in all cases divisible by 16 and by 3, and accordingly by 48.

II. *Solution by Nelson L. Roray, Metuchen, N. J., and R. W. Lord, Plainfield, N. J.*

Since n is even, then $n = 2a$

$$\begin{aligned} \therefore\ n(n^2+20) &= 2a[(2a)^2+20] \\ &= 8(a^3+5a) \\ &= 8(a^3+6a-a) \\ &= 8(a(a-1)(a+1)+6a) \\ &= \text{a multiple of 48, since the product of any 3 consecutive numbers is a multiple of 6.} \end{aligned}$$

473. *Proposed by Nelson L. Roray, Metuchen, N. J.*

ABCD is a parallelogram. On AB take AE, on DC take DF = AE. H is the mid-point of AE, I is the mid-point of FC. M is the median point of ΔAEF, N is the median point of ΔEFC. Prove MN, HI and BD are concurrent.

I. *Solution by Norman Anning, Chilliwack, B. C.*

Choose axes of coördinates so that the following points have the following coördinates:

A, $(0, b)$; B, $(0, 0)$; C, $(a, 0)$; D, (a, b); E, $(0, c)$; F, (a, c).

Since H is midway between A and E it will be $\left(0, \frac{b+c}{2}\right)$

Similarly I will be $\left(a, \frac{c}{2}\right)$

The coördinates of M, the median point of ΔAEF, are

$$\left(\frac{0+0+a}{3},\ \frac{b+c+c}{3}\right)$$

and of N, the median point of ΔEFC,

$$\left(\frac{0+a+a}{3},\ \frac{c+0+c}{3}\right)$$

The lines MN, HI, BD have, respectively, the equations:

$$\begin{aligned} 3bx+3ay-2ab-2ac &= 0, \\ bx+2ay-ab-ac &= 0, \\ bx-ay &= 0. \end{aligned}$$

These lines are concurrent, since

$$(3bx+3ay-2ab-2ac)-2(bx+2ay-ab-ac)-(bx-ay) \equiv 0.$$

474. *Proposed by G. I. Hopkins, Manchester (N. H.) High School.*

Two fixed tangents, a_1 and a_2, are drawn to a circle with center O. Any line through O meets a_1 in P_1 and a_2 in P_2. The second tangents through P_1 and P_2 intersect in P. Show that the locus of P is a circle with center O. (From a recent examination paper in elementary geometry.)

Solution by Murray J. Leventhal, Stuyvesant High School, New York City, Frank C. Gegenheimer, Marion, Ohio, and C. A. Nickle, State College, Pa.

Let a_1 and a_2 meet in A. $\Delta AP_1P_2 \cong \Delta PP_1P_2$, since two $\angle$s and the incl. side of one are equal respectively to the corresponding parts of the other. $\therefore AP_1 = PP_1$. Then, $\Delta PP_1O \cong \Delta AP_1O$ (Two sides and incl. $\angle$). $\therefore AO = PO$ no matter where P is. With O as a center and a radius equal to AO we have a circle, the locus of P.

475. *Proposed by Elmer Schuyler, Brooklyn.*

Prove, geometrically, that if a and b are the arms of a right triangle and c the hypotenuse, then

$$a+b \leqq c\sqrt{2}.$$

I. *Solution by R. M. Mathews, Riverside, California.*

On $AB = c$ as base construct the square ABDE overlapping the ΔABC. Prolong AC cutting diagonal EB at F; drop $EH \perp AC$.

Then $BC \leqq BF$ and $AC = EH \leqq EF$,

$$EB = c\sqrt{2}.$$

$$\therefore a+b \leqq c\sqrt{2}.$$

The case of equality arises when the rt. Δ is isosceles, and then F and H coincide at the center of EB.

II. *Solution by Clifford N. Mills, Brookings, S. Dakota.*

Given a right triangle ABC, the right angle at C, and $a < b$. Prolong CB to D making $BD = b$. At D construct $DK \perp CD$, having the same direction as CA, and $= a$. Join KB, and AK.

$AK = c\sqrt{2}$, and $DC = a+b$. Since $a < b$, then $A < B$. Hence $A < 45°$. But $\angle BAK = 45°$, and $\angle KAC < 90°$.

$\therefore$ AK is not $\perp$ to AC or KD. Hence $DC < AK$, or $a+b < c\sqrt{2}$. If $a = b$ then $a+b = c\sqrt{2}$.

III. *Solution by F. A. Kähler, New Trier Township High School, Kenilworth, Ill.*

Proof I. In ΔBOC where $\angle B = 45°$, the fact that $a+b = c\sqrt{2}$ is obvious.

II. In ΔBCA where $\angle B < 45°$.

Prolong BC through C making $CD = CA$.

Draw DA. Draw $AE = AB$ and $\perp$ to AB.

$\left.\begin{array}{l}\angle BEA = 45° \\ \angle CDA = 45°\end{array}\right\}$ isosceles rt. $\Delta \cdot \angle$s.

$\therefore$ a circle may be drawn through A, B, D, E. $\left\{\begin{array}{l}\text{Locus of the vertex of } \Delta \text{ having given base} \\ \text{and vert. } \angle \text{ is an arc of } \odot \text{ of which given} \\ \text{base is chord.}\end{array}\right.$

As $\angle BAE$ is rt. (construction)

BE is a diam.

$\therefore BE > BD$ (diam. is greatest chord).

$\therefore c\sqrt{2} > a+b$.

CREDIT FOR SOLUTIONS.

461. J. A. Lyons.

462, 463, 466. S. S. Wenkata Ramayer. (3)

467. S. R. Wenkata Ramayer, one incomplete solution. (2)

468. S. R. Wenkata Ramayer, Yeh Chi Sun, one incorrect solution. (3)

471. H. E. Anderson, Norman Anning, Roy W. Burns, M. J. Leventhal, R. M. Mathews, C. A. Nickle, F. M. Phillips, Nelson L. Roray, D. T Weaver. (9)

472. Norman Anning, Geo. Blanchard, R. W. Burns, Louis Clark, W. C. Eells, F. A. Kähler, M. Helen Kelley, M. J. Leventhal, R. W. Lord, L. E. Lunn, R. M. Mathews, Nelson L. Roray, D. T. Weaver, one incorrect solution. (14)

473. Norman Anning, W. C. Eells, F. A. Kähler. (3)

474. Verne Boulton, Frank C. Gegenheimer, F. A. Kähler, M. J. Leventhal, L. E. Lunn, R. M. Mathews, C. A. Nickle. (7)

475. F. A. Kähler, L. E. A. Ling, R. M. Mathews, Clifford N. Mills. (4)
46 solutions.

PROBLEMS FOR SOLUTION.

Algebra.

486. *Proposed by N. P. Pandya, Sojitra, Dt. Petlad, India.*

In a division, the dividend consists of five digits and the quotient exceeds the divisor by 16; the divisor exceeds the remainder by 55. Find (i) the least possible dividend; (ii) the value of the digit d if the dividend is $58d79$.

487. *Proposed by Albert Babbit, University of Minnesota, Minneapolis.*

If $c_0, c_1, c_2, \cdots c_n$ be the coefficients of the terms of the expansion $(1+x)^n$, show that $c_0-\frac{1}{2}c_1+\frac{1}{3}c_2-\cdots\frac{(-1)^n}{n+1}c_n=\frac{1}{n+1}$.

(From an examination paper of the Actuarial Society of America, May, 1915.)

Geometry.

488. *Proposed by Geo. Blanchard, Portland, Oregon.*

If α, β, γ be the distances from the vertices of a triangle to the points of contact with the inscribed circle, show that radius of circle has the value,

$$\left(\frac{\alpha\beta\gamma}{\alpha+\beta+\gamma}\right)^{\frac{1}{2}}$$

(From entrance examination Military Academy at Woolwich, England.)

489. *Suggested by Jack Benson, "Somewhere in France."*

[Relayed to the editor by Norman Anning.]

Given a triangle, to construct, in the simplest way, the line from which its area may be scaled.

Trigonometry.

490. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

If $A+B+C=180°$, show that unity is the least value of

$$\cot^2A+\cot^2B+\cot^2C.$$

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

231. *Proposed by S. R. Powers, Terre Haute, Ind.*

Is there a change in valence of nitrogen when ammonia gas combines with water to produce ammonium hydroxide? [Explain, using structural formulas showing position of all electropositive and electronegative charges.]

Answer questions numbered 232 and 233 in the succeeding list:

College Entrance Examination Board.

Comprehensive Examination in Physics, June, 1916—Two Hours.

A teacher's certificate covering the laboratory instruction must be presented as part of the examination, unless the laboratory notebook is to be presented at a laboratory examination.

Answer ten questions. Show clearly the method by which you obtain your answers, and state the units used in each case.

1. (*a*) What is meant by potential energy? by kinetic energy? Give examples.

(*b*) A body whose mass is 50 gm. is raised to a height of 300 cm. What is its potential energy?

(*c*) If it is allowed to fall freely, what will be its potential energy after it has fallen through a distance of 100 cm.? What is its kinetic energy at this point? What is the sum of these two energies?

(*d*) After it has fallen through the whole distance, 300 cm., what is its kinetic energy?

(*e*) What principle do the combined answers to (*b*), (*c*), and (*d*) illustrate?

2. Define coefficient of friction; mechanical advantage.

A boat weighing 1,800 lbs. is to be drawn to a point above high water level along a beach which rises 3 ft. in 10 ft. Make a sketch of a six-rope block and tackle adapted to the foregoing purpose, and calculate the force required, assuming the coefficient of friction between the boat and the beach to be 0.4.

3. Given a U-tube and some water: (*a*) Explain how you would determine the pressure of the illuminating gas in the pipes of a house; (*b*) explain how the result may be reduced to pounds per square inch. (One cubic foot of water weighs 62.4 lbs.)

232. A standard life preserver made of cork, the specific gravity of which is 0.14, measures 40 in.$\times$12 in.$\times$2 in.; what extra weight would the life preserver support when completely immersed in sea water of specific gravity 1.03. State the principle involved in the solution of the problem. (1 cu. ft. of fresh water weighs 62.4 lbs.)

5. The vibration frequency of two equal strings 5 ft. long is 236 vibrations per sec. How many beats per sec. will be heard when one of the strings has been shortened 1 inch?

6. Describe fully a laboratory experiment for determining the rate of vibration of some body emitting a sound.

7. What is the source of the heat which melts the ice in a tightly closed refrigerator?

233. If it requires 3 lbs. of ice to cool a gallon of milk (8.3 lbs.) contained in a glass jar weighing 4 lbs., from 75° F. to 40° F., what is the efficiency of the refrigerator? Assume specific heat of milk to be 1.0, specific heat of glass to be 0.12, and the latent heat of melting of ice to be 147 in the units here used.

8. A mass of 100 kgm. falls 10 meters. All of its energy is employed in stirring 1,000 gm. of water contained in a calorimeter which weighs 150 gm. (Specific heat, 0.1) The temperature is observed to rise 2°.3 C. Calculate the mechanical equivalent of heat.

9. Define coefficient of expansion. Describe a laboratory experiment by which the coefficient of expansion of some substance is determined.

10. What two classes of images are formed by a concave mirror? Show by diagrams the position of an image of each kind, and explain the principles underlying the construction of the diagrams.

11. How does the intensity of illumination at a point 2 ft. distant from a 32 candle power lamp compare with the intensity of illumination at a point 3 ft. distant from the same lamp? How far away from the above lamp should one's book be placed to secure an illumination upon its pages of 2 foot candles? (One foot candle is the illumination produced by a standard candle at a distance of one foot.)

12. Glass-bottomed boats are frequently used in the observation of the life in the ocean. Draw approximately the path of a ray of light, coming from a point some distance below the boat bottom and in the water, as it passes up through the thick glass bottom (index of refraction of glass, 1.5; of water, 1.33) (1) when the direction of the ray is perpendicular to the glass; (2) when the direction of the ray is oblique to the glass. Give reasons for your answers.

13. Describe briefly some form of galvanometer or ammeter, with diagrams if necessary, and explain its action as a measuring instrument.

A galvanometer or ammeter having a resistance of 10 ohms is to be connected so as to take only one-tenth of the total current in the main circuit. Explain how this may be done.

14. If an electric flatiron takes 5.3 amperes at 110 volts, what is the resistance of the heating element? How many watts of electric power are required to operate the apparatus? How many calories of heat should it develop in 10 minutes? How much does it cost per hour to run the flatiron at 10 cents per kilowatt hour. (1 watt second = 0.24 calories.)

15. Discuss the principle and the details of construction of a commercial transformer.

Why is it impracticable to transmit electrical power over great distances, such as from Niagara to New York City? What changes in the older methods of installation have led to considerable extensions in the practical working distances during the last decade?

A commercial transformer was placed on the outside of a building to change 220 volts to 110 volts for laboratory use. By mistake the line wires were connected to the secondary terminals. What voltage was obtained in the laboratory?

Solutions and Answers.

219. *Proposed by O. L. Brauer, Selma Union H. S., Selma, Cal.*

Is there a good illustration of a variable approaching a finite limit not zero? Namely, a physical illustration.

Answer.—The distance traveled by an elastic ball bounced on any elastic surface.

220. *Proposed by R. G. Rupp, Hammond, Ind.*

A piece of iron of density 7.5 floats in mercury (density = 13.5) and is completely covered with water which rests on the top of the mercury. How much of the iron is immersed in the mercury?

Solution by J. P. Drake, Emporia, Kan. Also solved by A. H. Smith, Riverside, Cal.

Consider the volume to be 1 cu. cm.
Let x = part in mercury.
and $1-x$ = volume in water.
Then x times $13.5+(1-x)1 = 7.5$ by Archimedes' principle.
Therefore $x = .52$, the part in mercury,
and $1-x = .48$, the part in water.

221. If a photographic print can be satisfactorily made in 20 seconds when placed 12 inches from a 16 candle power electric lamp, how long

will it take to make a print of the same intensity if a 32 candle power lamp is used at a distance of 24 inches? [10]

Solution by A. H. Smith. Also solved by J. P. Drake.

$20 : x :: (12)^2 : (24)^2$.
$x = 80$ sec., time required if c. p. of lamps had not been changed.
$80 : x :: 32 : 16$.
$2x = 80$.
$x = 40$ sec.—*Ans.*

222. An electric motor, having a speed of 1200 revolutions per minute, runs a sewing machine at a speed of 400 revolutions per minute; if the pulley on the motor has a diameter of $1\frac{1}{2}$ inches, what must be the diameter of the pulley on the sewing machine? [10] [Assume that the belt does not slip.]

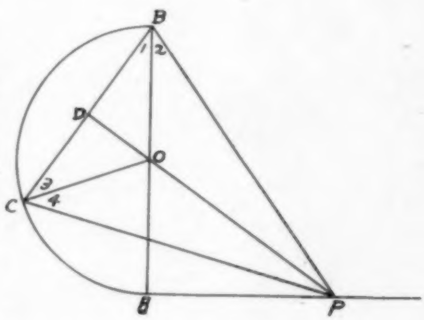
Solution by J. P. Drake.

The speed of the motor : speed of machine = 3 : 1.
∴ the circum. of motor pulley : cir. of machine pulley = 1" : 3.
∴ the diam. of motor pulley : diam. of machine pulley = 1 : 3,
or the diam. of the machine pulley is 4.5 inches.

223. *Proposed by R. E. English, Caldwell, Idaho.*

AB, the diameter of a semicircular mirror ACB, is 12 in. P is a luminous point in the tangent at A. How far from A must P be placed so that a ray of light reflected at B and C will return to P? What is the length of the ray's path?

Solution by A. Bjorkland, Harrison Tech. H. S., Chicago, Ill.



Solution: By law of reflection of light, angles 1 and 2, and 3 and 4 are equal, O being the center of the semicircle. By geometry, angles 1 and 3 are equal and therefore angle B equals angle C, and the angles at D are right angles. Also angle OPA equals angle 2 equals angle 1. Therefore the right triangles OAP, PAB and ODB are similar. Hence AP equals $\sqrt{2}\cdot r$; PB equals $\sqrt{6}\cdot r$ and BD equals $\frac{1}{3}\sqrt{6}\cdot r$. Since triangles PBD and PCD are alike, the length of the ray's path, PBDCP, equals $2(\sqrt{6}\cdot r+\frac{1}{3}\sqrt{6}\cdot r)$ $\frac{8}{3}\sqrt{6}\cdot r$. If r equals 6 inches, AP becomes 8.48 inches, and the ray's path becomes 39.19 inches.

224 *Proposed by O. L. Brauer, Selma Union High School, Selma, Cal.*

Balance the equation, $Cu+HNO_3 \rightarrow Cu(NO_3)_2+NO+H_2O$, without making any assumptions as to intermediate reactions.

Solution by A. Bjorkland. Also solved by R. W. Boreman and O. L. Brauer.

If x molecules of Cu react with one molecule of HNO_3 to form x molecules of $Cu(NO_3)_2$ and $\frac{1}{2}$ molecule of H_2O, then there remain $1-2x$ atoms of N and $3-6x-\frac{1}{2}$ atoms of O to form the reduction product. If, as in this problem, the reduction product is NO, then $(1-2x)/(3-6x-\frac{1}{2}) = 1$; whence $x = 3/8$, and $1-2x = 1/4$. Hence the relative number of molecules are 3/8, 1, 3/8, 1/4 and 1/2. Multiplying by 8, we have—

$$3Cu+8HNO_3 \rightarrow 3Cu(NO_3)_2+2NO+4H_2O.$$

If the reduction product has a different composition, then we have merely to substitute the new ratio of N to O, in the above equation and solve as before.

ARTICLES IN CURRENT PERIODICALS.

American Forestry, for August; *Washington, D. C.; $3.00 per year, 25 cents a copy:* "The Hickories—Identification and Characteristics" (with six illustrations), Samuel B. Detwiler; "Yellowstone National Park" (with six illustrations), Mark Daniels; "Bird Department," The Coloration of Birds, The Classification of Birds (with nine illustrations), A. A. Allen; "The Alternate Hosts of the White Pine Blister Rust" (with eighteen illustrations), Lawrence R. Grose; "Three Million Dollars for New England and Appalachian Forests"; "Southern Floods and their Forestry Lessons" (with nine illustrations), Herman H. Chapman.

American Botanist, for May; *Joliet Illinois; $1.00 per year, 25 cents a copy:* "Xenia in Maize," Adolph E. Waller; "The Licorice Plant," H. E. Zimmerman; "Vegetation of the Hawaiian Summitt Bogs," Vaughan MacCaughey; "Soap from Wild Plants," Charles F. Saunders.

American Journal of Botany, for July; *Brooklyn Botanic Garden; $4.00 per year, 50 cents a copy:* "The Development of the Phylloxera Vastatrix Leaf Gall," Harry R. Rosen; "Correlations Between Morphological Characters and the Saccharine Content of Sugar Beets," Frederick J. Pritchard; "Mutation in Mattiola Annua, a 'Mendelizing,' Species," Howard B. Frost; "The Growth of Forest Tree Roots," W. B. McDougall.

American Mathematical Monthly, for September; *5548 Kenwood Ave., Chicago; $3.00 per year:* "The Real Function Defined by $x^y = y^x$," E. J. Moulton; "Concerning Roulettes," Goldie Horton; "An Elementary Theory of the Exponential and Logarithmic Functions," E. V. Huntington; "Elementary Proof of a Theorem Due to F. Morley," Tobias Dantzig.

American Naturalist, for August; *Garrison, N. Y.; $4.00 per year, 40 cents a copy:* "The Form of Evolutionary Theory that Modern Genetical Research Seems to Favor," Dr. Chas. B. Davenport; "Comparative Rapidity of Evolution in Various Plant Types," Edmund W. Sinnott; "Egg Production and Selection," Dr. H. D. Goodale.

Condor, for May-June; *Los Angeles, Cal.; $1.50 per year; 30 cents a copy:* "The Shadow-boxing of Pipilo" (with five phoos), Donald R. Dickey; "A Populous Shore," Florence Merriam Bailey; "Nesting of the Bandtailed Pigeon in Southern Arizona" (with one photo), F. C. Willard; "The Speed of Flight in Certain Birds," Alexander Wetmore; "A Visit to Hat and Egg Islands, Great Salt Lake" (with five photos by A. O. Treganza), R. H. Palmer; "Nesting of the Tolmie Warbler in Yosemite Valley," Margaret W. Wythe; "Some Distributional Notes on California Birds," H. E. Wilder.

Geographical Review, for August; *Broadway, at 156th Street, New York City; $5.00 per year, 50 cents a copy:* "Biogeography of the Northern Great Plains " (1 map, 12 photos), Stephen S. Visher; "Salta, An Early Commercial Center of Argentina" (2 maps, 3 diagrs., 4 photos), G. M. Wrigley; "Pirate Coasts of the Mediterranean Sea" (3 maps), Ellen C. Semple.

Guide to Nature, for August; *Sound Beach, Conn.; $1.00 per year, 10 cents a copy:* "Flowers Pumping and Exploding," Herbert W. Faulkner; "Notes on the Two-Toed Congo Snake," R. W. Shufeldt; "The Brown Thrasher," L. W. Brownell.

Journal of Geography, for June; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "The Weather Factor in the Great War," IV, Robert DeC. Ward; "The Sod House as a Form of Shelter; Where? What? Why?" Louise W. Mears; "Little Holland," Nell G. Hudson; "A Neglected Source of Geographical Material," R. M. Harper.

Photo-Era, for August; *Boston, Mass.; $1.50 per year, 15 cents a copy:* "A Live Camera Club in Detroit," Philip M. C. Armstrong; "A Talk on Composition," The Walrus; "Two Neglected Processes of Reduction and Intensification," C. Welborne Piper; "A Weighing-Scale for the Amateur," Earl Stafford; "One-Lens Stereoscopic Photography," E. L. Austen.

Popular Astronomy, for August-September; *Northfield, Minn.; $3.50 per year:* "The Function of the Van Vleck Observatory, Frederick Slocum; "Our Solar System," Percival Lowell; "The History of the Discovery of the Solar Spots," (Continued), Walter M. Mitchell; "Evidences of Erosion on the Moon," William H. Pickering.

Physical Review, for August; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Electromotive Force Produced by the Acceleration of Metals," Richard C. Tolman and T. Dale Stewart; "Compton's Formula for the Temperature Variation of the Specific Heat of Solids," F. Schwers; "On the Electrostatic Measurements of Electrode Potentials," G. Borelius; "A Study of the Law of Response of the Silicon Detector," Louise S. McDowell and Frances G. Wick; "Some Properties of Mercury Droplets Important in Electronic Charge Measurements," L. W. McKeehan; "The Evaporation, Condensation and Reflection of Molecules and the Mechanism of Absorption," Irving Langmuir; "The Mechanical Equivalent of Light as Determined from the Brightness of the Black Body," Herbert E. Ives and E. F. Kingsbury; "The Effect of Temperature on the Light-Sensibility Curves of Different Types of Selenium Cells," E. O. Dieterich; "The Measurement of Time with a Moving Coil Galvanometer," Paul E. Klopsteg; "Phenomena Attending the Passage of X-Rays through Narrow Apertures," E. G. Taylor.

School World, for August; *Macmillan Company; St. Martin St., London, W. C.; 7s. 6d. per year:* "The Place of Science in Education," Dr. J. A. Fleming; "Education and Machinery," E. Sharwood Smith; "The State and Science."

Scientific Monthly, for September; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "The Scientific Investigation of Cancer." Dr. Leo Loeb; "Insect Migrations as Related to Those of Birds," Howard J. Shannon; "Substances without Chemistry," Dr. John Waddell; "A Glance at the Zoology of Today," H. V. Wilson; "The Oceans, Our Future Pastures," Zonia Barber; "Science and Feminism," Dr. Robert H. Lowie and Dr. Leta Stetter Hollingworth; "The Origin and Evolution of Life upon the Earth," Dr. Henry Fairfield Osborn.

BACK NUMBERS WANTED.

25 cents per copy will be paid, or 50 cents allowed on subscription for No. 43, Vol VI, May, 1906.

THE ORIGIN OF GOLD AND SILVER.

Steamboat Springs, Nev., has figured prominently in discussions of the origin of ore deposits. The waters of these springs contain the precious metals in minute quantities, and the sinter deposited by them contains several minerals that are common constituents of ores, as well as small quantities of many of the rarer metallic constituents of ore deposits, including gold and silver. Such springs, therefore, suggest that many and perhaps most ore-bearing veins have been formed by hot waters rising from great depths, which have brought their metal contents up in solution and deposited them in open spaces or fissures in the rocks through which the waters passed, the deposition of some ores being influenced by chemical reaction with the surrounding rock. Many ore deposits are undoubtedly formed in other ways, for some are unquestionably of sedimentary origin and the metal content of some others has been carried down, redeposited, and concentrated by rain water that descended into the earth's crust, but the "hydrothermal" origin—that is, their deposition from ascending hot water—of many of the more valuable ore deposits is indicated by the close relation observed at many places between mineral veins and eruptive rocks. Thermal waters are believed to be in part, at least, given off by slowly cooling and solidifying masses of igneous rock (magma) deep within the earth.—*U. S. Geological Survey.*

THE CENTRAL SCIENTIFIC COMPANY.

It is a pleasure to record the stages in the growth of an apparatus house which has earned so favorable a standing among science teachers as has the Central Scientific Company, and the recent removal of this concern to commodious quarters on the Lake Shore Drive, Chicago, appears worthy of comment The older readers of School Science and Mathematics will recall the article which appeared in the June, 1906, number relative to the reorganization in 1904 of the Central Scientific Company, and its quarters in the building then known as 14-28 Michigan St., Chicago. After twelve years of growth in this location during which it expanded until it occupied all available space in the building, and as entrances and street names changed, took successively the addresses 345-359 W. Michigan St., and 412-429 Orleans St., it became necessary for the company to seek larger quarters.

These were found at 460 East Ohio Street in a six story building extending 240 feet along Lake Shore Drive from Ohio to Ontario Street, where the total space occupied by the firm is nearly two and one-half acres. On the first floor is situated the engine room and the shipping platform, together with generous storage space. The main portion of the second floor is given over to a large show room and a spacious and well arranged office, and the Ontario Street section is occupied by the receiving room for incoming freight and express matter. The chemical department occupies a large portion of the third floor, together with the glass-blowing department. The fourth floor is occupied by the factory, which is still in charge of the original superintendent, Mr. Frank Aronson, while the fifth and sixth floors are given over to the shipping and stock rooms.

The original officers, Messrs. A. H. McConnell, H. C. Arms and J. M. Roberts, are still with the company, the only change in the list having come through the withdrawal in June, 1915, of Mr. A. H. Standish, who had up to that time so capably filled the position of treasurer.

These gentlemen have now associated with them in the advertising, sales and manufacturing departments Mr. Chas. W. D. Parsons, formerly of the Evanston, Ill., Township High School, Colorado College and Northwestern University, Mr. W. H. Farr, formerly of the University of Iowa, Mr. S. L. Redman, formerly of Harrison Technical High School, Chicago, and State Manual Training Normal School, Pittsburg, Kansas, Mr. H. V. Cadwell, formerly of the University of Kansas, and Mr. A. B. Carter, formerly of Purdue University and the University of Chicago.

The company is to be congratulated on the increased facilities due to larger quarters and the augmented staff of assistants, and can undoubtedly look forward to many years of successful service to the science teachers of this country as well as of foreign lands.

NEW YORK ENTERS THE LIST OF ZINC PRODUCERS.

In 1915, the zinc properties in St. Lawrence County, N. Y., were actively developed, and a 200-ton mill was in successful operation during the latter part of the year. The Northern Ore Company was the only producer of zinc in the state in 1915, though it is probable that at least one other company will operate in 1916.

THE AMERICAN PHYSICAL SOCIETY AND THIS JOURNAL.

In order that the secondary school instructor and the university professor may be brought closer in touch with the work of each, the American Physical Society and this Journal have entered into an agreement whereby this result, it is expected, will be accomplished.

Professor H. L. Dodge of the University of Iowa has been appointed to take charge of the work for the Society. It is hoped that this movement will meet with the approval of all physics teachers and that they will cooperate in every way possible to make this scheme a success. One method by which this can be done will be by submitting to the editors short articles on how you do your teaching in lecture, recitation and laboratory. Let the Journal hear from you.

A GENERAL SCIENCE CLUB ORGANIZED.

Two General Science Conferences have been held this year at the Salem State Normal School, Massachusetts. These were attended by New England teachers chiefly, but four were from New York and one from Illinois.

The first meeting considered the high school problems, and the discussion was led by Prof. Woodhull of Teachers College, Prof. Mann of the Carnegie Foundation, and Mr. Orr, Deputy Commissioner of Education. The second meeting was primarily to interest superintendents and elementary school teachers in general science for the elementary schools. The speakers were Prof. Kilpatrick, Teachers College, New York, Mr. Sherman of Boston, and Mr. Lunt of Boston.

As an outcome of these two meetings, the *General Science Club* was organized, which admits anybody *interested* in general science to membership. The membership fee is one dollar. The following officers were elected for the ensuing year:

President—Mr. Walter G. Whitman, State Normal School, Salem, Mass.

Vice-President—Mr. Samuel F. Tower, English High School, Boston, Mass.

Secretary—Mr. George C. Francis, Center School, Everett, Mass.

Treasurer—Mr. Arthur H. Berry, High School, Newburyport, Mass.

RADIUM NEVER SEEN IN NATURE.

Radium is a metal and is described as having a white metallic luster. It has been isolated only once or twice, and few people have seen it. Radium is ordinarily obtained from its ores in the form of hydrous sulphate, chloride, or bromide, and it is in the form of these salts that it is usually sold and used. These are all white or nearly white substances, whose appearance is no more remarkable than common salt or baking powder. Radium is found in nature in such extremely small quantities that it is never visible even when the material is examined with a microscope. Ordinarily, radium ore carries only a small fraction of a grain per ton of material, and radium will never be found in large quantity because it is formed by the decay of uranium, a process which is wonderfully slow, and radium itself decays and changes to other elements so rapidly that it is impossible for it to accumulate naturally in visible masses. Minerals that carry radium, however, are fairly easy to determine. One of them, pitchblende, as generally found, is a black mineral about as heavy as ordinary iron, but much softer. The principal radium mineral, carnotite, has a bright canary-yellow color, and is generally powdery. There are other radium-bearing minerals of less importance.—U. S. Geological Survey Bulletin.

RUBBER AS A SOURCE OF DANGER.

Everyone is interested in the chemistry of rubber because this material enters into numerous articles and devises of daily use. Experience teaches the unlike qualities of different types or brands of rubber. Some of them retain their original elasticity for a long time under the imposed conditions of usage, while others speedily deteriorate into brittle and useless scrap, despite the various precautions of preservation that are embodied in familiar directions. The economic aspect of the quality of rubber goods offered for sale is an important one.

The time is arriving, says *The Journal of the American Medical Association*, when the purchaser of rubber will demand some reliable information as to the quality of the product which he is paying for. Rare, indeed, is the person at the present time who has any idea whatever of the make-up of rubber. Pure India rubber, or caoutchouc, in its natural state is entirely unsuited for commercial use. It is soft and sticky, and readily undergoes spontaneous oxidation to a hard, brittle, resinous substance. By vulcanization, a process in which mixtures of the crude gum with sulphur, or metallic sulphides or oxides are heated, a rubber is formed which is more permanently elastic and less subject to spontaneous change. The simplest type of vulcanized rubber, such as would be obtained from a properly heated mixture of sulphur and pure gum, is quite soft and offers little resistance to ordinary rough usage. Rubber of tougher qualities, but with lower elastic limits, is produced by the addition of metallic oxides, such as those of lead and of zinc, to the other ingredients before vulcanization. Among other constituents added to give required characteristics are the various pigments which furnish the color, Venetian red (iron oxide), ultramarine, lampblack and various organic dyes being among the ingredients which are employed.

A recent government report shows that a large number of materials are used in rubber compounding to reduce the cost. Among these are whiting, barytes, clay and various rubber substitutes, such as artificial rubber, oils and tar products. Finally, so-called recovered rubber, or shoddy, is used to a large extent in rubber compounds. In the case of most articles of rubber, the existence of filling materials, pigments, etc., has no hygienic import. Cost and durability are the chief concern of the purchaser. The use of various heavy metals in the manufacture of nursing-nipples and small rubber toys is a danger to the health of infants, who extract soluble products from such articles in the mouth or when small pieces of rubber are accidentally swallowed.

The Public Health Service has lately investigated the rubber used in nipples and toys. All specimens examined contained iron and aluminum. In the red rubbers, either zinc oxide or magnesia was used, in the black rubbers zinc oxide and barytes. Antimony was found in four cases out of seven among the black rubbers, and in five cases out of eight among the red rubbers. The three remaining specimens of red rubber were colored with Venetian red. The white rubber toys contained clay, zinc oxide and barytes. The use of lead compounds in rubber preparations is common, and salts of mercury are used to some extent. Either of these metals would be highly objectionable in nipples or children's toys. The government report concludes: The articles should be made of a good grade of black rubber, free from shoddy and from antimony, lead, arsenic and mercury. Of the fillers commonly employed, magnesia, zinc oxide and clay are less undesirable, and barytes is probably without harmful influence. There can be no objection to a red rubber colored with iron oxide, although the advantages of such a compound will probably not compensate for the disadvantages of its being confused with antimony rubber.

COAST AND GEODETIC SURVEY HAS NEW ELECTRIC SIGNAL LAMP VISIBLE ONE HUNDRED MILES WITH NAKED EYE.

Mr. E. G. Fischer, Chief of the Instrument Section of the Coast and Geodetic Survey, Department of Commerce, has just completed the design and construction of a signal lamp which will be used during the coming summer in the mountainous regions of Idaho and Oregon on primary triangulation, where the distance between stations is frequently as much as one hundred miles. This lamp has been tested by the Bureau of Standards and is shown to be more than 150 times as powerful as the acetylene signal lamps which have been used for a number of years by the Survey. These acetylene lamps have been observed with the telescope over lines more than 120 miles in length. The new lamp is an electric one, with a specially designed filament, and the power is the ordinary dry cell. While no tests have been made on the field with the new lamp, it is expected that ordinary haze or smoke will seldom prevent observations.

The Bureau of Standards states that the larger sizes of this lamp are so powerful as to be scarcely comparable with the acetylene lamp.

NEW SCHOOL USE OF TOPOGRAPHIC MAPS.

A recent writer in the civic and country welfare journal, *The Survey*, describes the latest contribution to the "keeping of children on the farm" movement. In the country schools of Sauk County, Wis., the children make an inventory of the agricultural investment of the townships in which they live, and each special feature is represented on a topographic map. The results are "cow maps," "corn maps," and a census of farm machinery and farm and home conveniences. In this extensive as well as intensive educational work which together constitute a social survey of the country, the topographic maps of the United States Geological Survey are used as base maps on which to plat the special information gathered. In their use of these maps, the school children obtain new ideas of geography and of the real significance of maps. The standard topographic map is sold at ten cents a copy by the Geological Survey, Washington, D. C.

ALASKA SMASHES RECORDS.

The value of the mineral production of Alaska in 1915 amounted to $32,854,229—$13,788,563 more than the value in 1914 and far more than that of any previous annual output during the thirty-six years that mining has been carried on in the Territory. The collection of mineral statistics of Alaska for 1915, just completed by Alfred H. Brooks of the United States Geological Survey, shows that the value of the gold produced during the year amounted to $16,702,144, copper $15,139,129, and silver $543,393. Tin, lead, antimony, marble, gypsum, and a small amount of petroleum and coal bring the total value of Alaska's mineral products to $32,854,229.

Since 1880, when mining first began in Alaska, the Territory has produced gold, (silver, copper, tin, and other minerals to the value of $300,953,751, the gold production alone to the close of 1915 amounting to $260,858,943. Of this gold, $186,192,992 worth was produced by the placers, the rest being derived from lode deposits.

BOOKS RECEIVED.

The Life of Inland Waters, by James G. Needham and J. T. Lloyd, Cornell University. 438 pages. 16.5x23.5 cm. Cloth. 1916. $3.00. Comstock Publishing Company, Ithaca, N. Y.

The Origin of the Earth, by Thomas C. Chamberlin, University of Chicago. Pages xi+271. 13x19 cm. Cloth. 1916. $1.50 net. Wt., 1 lb. 6 oz. University of Chicago Press, Chicago.

The Principles of Health Control, by Francis M. Walter, Normal School, Warrensburg, Mo. Pages viii+476. 13.5x19 cm. Cloth. 1916. $1.20. D. C. Heath & Company, Boston, Mass.

Organic Agricultural Chemistry—The Chemistry of Plants and Animals—For Use in Colleges, by Joseph S. Chamberlain, Massachusetts Agricultural College. Pages xvii+319. 14x20 cm. Cloth. 1916. $1.60 The Macmillan Company, New York City.

The Avoidance of Fires, by Arland D. Weeks. North Dakota Agricultural College. Pages v+128. 12x17 cm. Cloth. 1916. 60 cents. D. C. Heath & Company, Boston, Mass.

General Science, by Lewis Elhuff, George Westinghouse High School, Pittsburgh, Pa. Pages viii+433. 13.5x19 cm. Cloth. 1916. $1.20. D. C. Heath & Company, Boston, Mass.

Descriptive Catalogue of Books by D. C. Heath & Company. 307 pages. 13x18.5 cm. Paper. 1916. D. C. Heath & Company, Boston.

Teaching Elementary Science in Elementary Schools, by J. Edward Mayman, New York University. 164 pages. 14.5x21.5 cm. Paper. 1915. Department of Education, New York City.

1005 Problems and Questions in Physics, by Franklin T. Jones, University School, Cleveland, Ohio. 84 pages. 13.5x19 cm. Paper. 1916. 40 cents. University Publishing Company, Cleveland, Ohio.

Laboratory Exercises in the First Year of Science, by Dr. John C. Hessler, James Milliken University, Decatur, Ill. Pages vi+118. 14x19.5 cm. Cloth. 1915. Benjamin H. Sanborn & Company, Chicago.

Plant Anatomy from the Standpoint of the Development and Function of the Tissues—A Handbook of Microtechnique, by William C. Stevens, University of Kansas. Pages vii+399. Paper. 1916. $2.50 net. P. Blakiston's Son & Company, Philadelphia.

Elementary Manual in Microbiology, by Ward Giltner. Pages xvi+418. 13.5x19.5 cm. Cloth. 1916. John Wiley & Sons.

Flora of the Northwest Coast, by Charles V. Piper and R. Kent Beattie. Pages xiv+418. 15x23 cm. 1915. $1.75 postpaid. Sold by Wash. State College, Pullman, Wash.

Catalog of the University of South Carolina for 1915-1916. 167 pages. 15x23 cm. Paper. Published by the University at Columbia.

Trigonometric and Logarithmic Tables, by George Wentworth and David Eugene Smith. Pages iv+104. 15x24 cm. Cloth. 1914. 60 cents. Ginn & Co., Boston.

The Carnegie Foundation for the Advancement of Teaching. Tenth Annual Report of the President and Treasurer. Pages vi+141. 18.5x25.5 cm. Paper. 1915. 576 Fifth Ave., New York City.

Sex Education, by Maurice A. Bigelow, Teachers' College, Columbia University. Pages xi+251. 13x19 cm. Cloth. 1915. $1.25. Macmillan Company, New York City.

Social Problems. A Study of Present Day Social Conditions, by Ezra T. Towne, Carleton College. Pages xviii+406. 14x19 cm. Cloth. 1916. $1.00. Macmillan Company, New York City.

Hospital Laboratory Methods for Students, Technicians and Clinicians, by Frank A. McJunkin, Marquette University of Medicine. Pages xi+139. 14x20 cm. Cloth, 1916. $1.25 net. P. Blakistons' Son & Co., Philadelphia.

MAGNETIC TESTING.

The Bureau of Standards, of the Department of Commerce, has just issued a revised edition of its Circular No. 17 on *Magnetic Testing,* which deals with the data required for ordinary engineering purposes. The fundamental magnetic quantities, which are those commonly used in engineering or technical work, are defined, and the question is considered as to what extent the complete magnetic data must be given to define the magnetic characteristics of a material.

The scope of the work of the Bureau in magnetic testing is outlined, giving the size of test pieces required, and the data ordinarily required for various engineering needs. The methods of testing are described in some detail, calling attention to the difficulties and sources of error and the importance of proper sampling.

Typical data and curves are given for representative materials in commercial use. These include materials for permanent magnets, electromagnets, armatures, transformer cores, etc. A table is also given, showing the magnetic susceptibility of the chemical elements, together with a few of the more important compounds.

Considerable attention is given to an analysis of some of the empirical formulas which express the relations between the various magnetic quantities. These formulas are useful in indicating the behavior that may be expected of materials under conditions other than those under which they have been tested.

The circular concludes with a list of the publications of the Bureau of Standards on magnetic subjects. The publications of the Bureau of Standards are for free distribution and will be sent to interested parties upon application to the Bureau at Washington, D. C.

BOOK REVIEWS.

The Origin of the Earth, by Thomas C. Chamberlin, University of Chicago. Pages xi+271. 13x19 cm. Cloth. 1916. $1.50. Wt., 1 lb., 6 oz. University of Chicago Press, Chicago.

One of the most interesting, valuable and useful books that have recently come from the press is the one by this celebrated scientist. It consists of ten chapters, and is written in such a wonderfully interesting and convincing style that those who are inclined toward the study of geology and matters appertaining to the history of the earth cannot help but be attracted by what the author has to say. The various theories concerning the origin of the earth are discussed, and the author's own splendid hypothesis is apparently substantiated in every particular. At the end of each chapter is a list of references bearing upon the subject matter contained therein. There are some interesting and original figures and photographs published. There is a good index of nine pages appended. The volume deserves and doubtless will have a very extensive sale. Every person interested in any phase of geology should possess a copy. C. H. S.

General Science, by Lewis Elhuff, George Westinghouse High School, Pittsburgh, Pa. Pages viii+348. 13.5x19 cm. Illustrated. Cloth. 1916. $1.20. D. C. Heath & Company, Boston, Mass.

During the last three or four years, many high-class texts on general science have come from the press, and this one is of just as high a standard and character as any which have recently been published. The

fundamental purpose of the book is to develop in the mind of the pupil an interest in science, and to teach him to observe accurately and intelligently. The book discusses hygiene, plant and animal life, earth science, chemistry of the most common things, and the elementary facts and laws of physics. It attempts to instruct the pupil in the very obvious things that have come to the pupil's view, and which are indeed in the environment in which he lives. While the field of general science is of necessity very wide and complicated, there are certain fundamental and underlying ideas which the young secondary school pupil may well study to advantage, and it is to gain a knowledge of these principles that this text has been prepared. There are many questions and exercises scattered throughout the book. The illustrations and drawings are very numerous, many of them being used in the book for the first time. All major paragraphs begin with bold-faced type. Mechanically and typographically, the volume is well made, and will stand strong and desperate usage. Principals and superintendents having in mind the establishment of a course in general science should examine this text thoroughly with a view to adopting it before they decide upon any book.

C. H. S.

The Avoidance of Fires, by Arland D. Weeks, North Dakota Agricultural College. Pages v+128. 12x17 cm. Cloth. 1916. 60 cents. D. C. Heath & Company, Boston, Mass.

Books are made to read and study. This little volume is no exception to the rule. It has been written fundamentally for the purpose of urging people to be more careful and conservative when they are dealing with fire or with materials that are liable to take fire. It impresses upon one the very important fact that when valuable material of any kind is destroyed by fire, the world as a whole suffers an inevitable loss. An attempt is made to arouse an interest in the avoidance of fire waste of all kinds. The little book can well be used as a textbook in any secondary school. There are many tables of statistics scattered throughout the text, which are indeed very interesting. The one on page 80, giving the various causes of fire in the year 1914 by the Fire Marshal of Iowa, is indeed enlightening. It shows that the great majority of the fires in that state during that year might have been prevented with proper education. Every teacher and layman should secure a copy and read it. C. H. S.

The Principles of Health Control, by Francis M. Walter, Normal School, Warrensburg, Va. Pages viii+476. 13.5x19 cm. Cloth. 1916. $1.20. D. C. Heath & Company, Boston, Mass.

Of the making of good books nowadays, there is, apparently, no end. This one is surely of the highest type of texts that have recently come from the press, bearing upon the subject in question. The fundamental difference between this book and so many that have appeared recently is that this one lays strong emphasis upon corrective work in hygiene, thus giving practical operation to the old phrase, "An ounce of prevention is worth a pound of cure." The control of one's health is here discussed through all of the various phases which must necessarily enter into the government of health. Emphasis is laid, too, upon encouraging the individual to make use of his common sense and the knowledge at his command, to govern and exercise his various functions and habits in those ways which will not tend to destroy tissue and energy, but on the other hand will cause the building up of all parts of the system in such a way as to make the individual's health as nearly perfect as possible under the circumstances and environment in which the particular

individual is obliged to live. All major paragraphs of the book begin with bold-face type, and the word or phrase at the beginning is a key to the matter which is discussed in these major paragraphs. At the end of each chapter, there are given many practical exercises, and a kind of laboratory display of matters which will enable the person performing them to not only increase his own tendency to maintain health but endue him with a spirit of teaching others to do the same. There are in the text ninety-five very apt illustrations and cuts. The method of treatment is splendid, and is of such a nature as to interest all people who have any desire to preserve their own health and that of the community in which they live. A very complete index of fourteen pages is given at the end. It is a book that all teachers of physiology and hygiene should possess. C. H. S.

Laboratory Exercises in the "First Year of Science," by John C. Hessler, James Milliken University. Pages vi+118. 14x19.5 cm. Cloth. 1915. Benjamin H. Sanborn & Company, Chicago.

This is a laboratory manual prepared expressly to accompany the author's *First Year of Science,* and it consists of 107 well-selected exercises. It is written in a way such that a young person will readily understand and grasp the meaning of the experiments, at the same time being able to perform them with a minimum amount of help and yet securing a maximum amount of information. C. H. S.

The Science of Musical Sounds, by Dayton C. Miller, Case School of Applied Science, Cleveland, Ohio. Pages xxiv+286. 14.5x22 cm. Cloth. 1916. The Macmillan Company, New York City.

This is one of the most interesting books to people interested in physics that have come from the press in a long time. It consists of a series of eight lectures which were given at the Lowell Institute in January and February, 1914, under the general title of "Sound Analysis." The lectures have been remodeled so that they could be presented in the form in which they are found in the volume. There is no one person who is so thoroughly familiar with the science of musical sounds and their method of graphical presentation, discussion and interpretation as the author of the book. Of necessity, the theory of the science is avoided as much as possible, but there can be no doubt but what a desire for extended study and investigation will be created in the minds of all people inclined toward this science, by a study of this book. The references are all collected in an appendix of nine pages. There are 186 figures and cuts in the text. Most of these are reproductions by the author himself from his apparatus and investigations. The work is something which every person interested in this branch of physics should secure and read. C. H. S.

Teaching Elementary Science in Elementary Schools, by J. Edward Mayman, New York University. 164 pages. Paper. 1915. Department of Education, State of New York.

This represents a very serious and thorough survey of the various methods in existence for the teaching of elementary science in elementary schools. It is full of very helpful suggestions and shows the status of the best methods now in use for the presentation of this subject. There are numerous footnotes to authorities quoted, showing that the author has been very painstaking in his investigations. There is a splendid bibliography appended, and altogether it is a book that should be studied by every teacher who is attempting to teach science not only in the elementary schools but in the high schools as well. C. H. S.

Problems and Questions on Physics, by Franklin Turner Jones, University School, Cleveland, Ohio. 83 pages. 13.5x19.5 cm. Paper. 1916. 40 cents. University Publishing Company, 7117 Hough Ave., Cleveland.

This represents a compilation of the entrance examination questions in physics from the college examination board and many of the larger schools in the East, together with a large number of questions which have been set by individual teachers. There are in the book 1,005 pertinent and up-to-date questions This affords one of the very best means for a rigorous review in physics. No teacher of the subject can afford to be without a copy. Indeed, it would be well worth while for every teacher in physics to have each and every pupil possess a copy.

C. H. S.

Diamonds—A Study of the Factors that Govern their Value, by Frank B. Wade, Shortridge High School, Indianapolis, Indiana. Pages viii+150 13x19 cm. Cloth. 1916. G. W. Putnam's Sons, New York City.

A book which represents the results of the author's study and investigation on the subject of precious stones, extending over a period of fifteen or more years. The particular part of the book that is of the highest interest is that which deals with the original study, which attempts to discover the reason of various effects, and to explain the causes of the peculiar refraction, absorption, and diffusion of light by precious stones. It is a book which all jewelers or dealers in diamonds should possess, and at the same time that small portion of the American people who can afford to buy diamonds should possess the book in order to familiarize themselves thoroughly with the diamond and other stones. It is an interesting piece of work for all laymen. C. H. S.

Fundamental Conceptions of Modern Mathematics, by Robert P. Richardson and Edward H. Landis. Pages xv+216. 14x20 cm. $1.25 net. 1916. The Open Court Publishing Company, Chicago.

This book is the first of a series designed to cover all the fundamental concepts of Modern Mathematics. It is, however, complete in itself, dealing with the most fundamental questions which arise in mathematical science. The author's purpose to furnish a clear and precise explanation of the various types of quantities represented by the symbols of mathematics, to give an account of quantities and their classification, including those of quaternious and of all other branches of algebraic science, and to consider the constitution of variables and the essential characteristics of a functional relation between variables.

From a very complete table of contents, a few topics are chosen to indicate the character of the work. "Origin of the Conception of a Variable and of a Name;" Natural Numbers;" "Value Classes;" "Variable Classes;" "Theory of Point Aggregates;" "Order in Space, Order in Time, Order in Value;" "Sorts of Quantities;" "Distinction between Positive and Negative with Complex Quantities;" "Units;" "Quaternious;" "Non-zeroes;" "The Doctrine of Number;" "Classification of Algebras;" "The Symbolic Logicians;" "A Variable is not a Set of Quantities;" "Series;" "On the General Conception of Functional Relation."

For the most part, teachers of secondary mathematics are interested in mathematics solely as an art; but it would be to their advantage to read and study a book like this which reveals the philosophical side of the subject and the basis of its scientific development. H. E. C.

Laboratory Manual in Microbiology, by Ward Giltner. Pages xvi+418. 13.5x19.5 cm. 1916. John Wiley & Sons.

This manual emanates from the same laboratory with Marshall's *Microbiology* which was reviewed in this Journal in 1912. Although published by different houses, the two books are adapted to go together.

The directions for the various exercises are clear, concise, and workable. Obviously the book is the outgrowth of actual classroom work. The total number of exercises is 125. Fifty-three of these are concerned with the general technique of bacteriology. Thirty-three are given the study of the physiology of microorganisms, and the remainder to the microbiology of air, soil, water and sewage, dairy, and animal diseases. The book will be particularly useful in agricultural colleges.

Secondary school teachers will find much good reference material here. Particularly will the detailed exercises on technique enable teachers not especially trained in bacteriology to become familiar with culture methods and media. Considerable descriptive and historical material is included. W. L. E.

Soils, Their Properties and Management, by T. L. Lyon, E. D. Tippin, and H. O. Buckman. Pages xxii+764. 2.5x19 cm. 1915. Macmillan.

This text is an addition to Macmillan's *Rural Textbook Series* and is intended for classroom use. It is an extended and detailed treatise on the soil in all its important aspects and contains as complete discussion as would be desired by anyone not a specialist in soils. The authors do not indicate the grade in which they expect the book to be used, but they take for granted a knowledge of physics and chemistry which would not be in the possession of the pupil before the first college years.

As a textbook, it belongs to the college, but as a reference work it might well find a place on the shelves of every teacher of botany and agriculture.

The Wheat Industry, by N. A. Bengston and Donee Griffith. Pages xiv+341. 13x19 cm. 1915. Macmillan.

This book is an account of the wheat industry of the world with particular reference to the United States. It includes cultivation, harvesting, marketing, transportation, storage, milling, and consumption, together with a survey of the principal wheat-producing countries. It is illustrated by 134 well-chosen figures, mostly photographs.

The book is intended for school use and would be very serviceable for supplementary reading in classes in botany, agriculture, geography, or domestic economy. W. L. E.

The Principles of Agronomy, by F. S. Harris and George Stewart. Pages xvii+451. 12.5x19 cm. 1915. MacMillan.

This is another of the rural textbooks. This one is adapted to high school use. There are four chapters on the plant, similar to the treatment in textbooks of botany, ten chapters on the soil, thirteen on particular field crops and crop improvement, and four on farm management.

Some parts of the book appear rather difficult for general high school use, and it is possibly better adapted to agricultural college use in the short courses or in the later years of the high schools. Some knowledge of chemistry and physics would be highly desirable. W. L. E.

Laboratory Manual of Horticulture, by George W. Hood. Pages vi+234. 15x23 cm. 1915. $1.00. Ginn & Co.

Seventy-eight exercises in practical horticulture as used in his classes by the author are included in this volume. It is a college book but many of the exercises are adaptable to more elementary use.

W. L. E.

Practical Lessons in Agriculture, by Lester S. Ivins and Frederick A. Merrill. Pages vi+223. 18.5x23.5 cm. 1915. American Book Company.

This text consists of 142 lessons grouped by months from September to May. Some lessons are wholly didactic, some are laboratory lessons, and others are combinations of the two methods.

The book is intended by the authors for use in grades seven to ten; and it appears to be well adapted to these grades. The fact that considerable textbook material appears in the book makes it possible to carry on the work without any other text, particularly if supplementary reading is possible. W. L. E.

Flora of the Northwest Coast, by Charles V. Piper and R. Kent Beattie. Pages xiv+418. 15x23 cm. 1915. $1.75 postpaid. Sold by Wash. State College, Pullman, Wash.

This manual covers the region from the Cascade Mountains to the Pacific Ocean, and from the headwaters of the Willamette River north to the international boundary. It will be noted that only a limited region is covered, but this area is of great interest on account of its great coniferous forests, its mountain meadows, the great range of altitude within short distances, the wide variations in humidity, and the large proportion of species not found other places.

The book is provided with an analytical key to families, and in many cases to genera as well. The generic and specific descriptions are full and definite. There are described sixty-one species of Pteridophytes, twenty-two Gymnosperms, 412 Monocots, and 1,122 Dicots. The book will be a necessity for botanists in the Northwest, and it will be highly desirable for any traveler in that region who has botanical inclinations.

W. L. E.

Soils and Plant Life, by J. C. Cunningham and W. H. Lancelot. Pages xxii+348. 12.5x19 cm. 1915. MacMillan.

A combination of textbook and laboratory manual. Considerable emphasis is very properly laid upon the laboratory work, but it is interesting to note that there are forty-five exercises in the first half of the book as against seven in the latter half. The book is stated by its authors to be intended for the rather wide range included in "rural grade, and high schools." It appears to be actually of high school grade. Five chapters are given to the soil, ten to plant structure and physiology, and seven to particular crops.

W. L. E.

A Spring Flora for High Schools, by Henry C. Cowles and John G. Coulter. 144 pages. 12.5x18.5 cm. Cloth. 1915. American Book Company, Chicago.

This little book contains descriptions of 380 species of early-flowering plants found in the North, Central and Eastern States. The keys are simple and workable and the descriptions are as untechnical as consistent with exactness. A large number of the genera are illustrated with very useful line drawings.

The obvious objection to any restricted flora is found in the omission of species which though generally rare may be locally abundant. When a pupil has several times failed to identify his find on account of the inadequacy of the flora, he is likely to lose interest. However, this situation is unavoidable, unless the complete manuals are used. This little book solves the difficulty more satisfactorily than usual. The grasses and sedges, as well as most of the willows and hawthorns are ommitted. Since these groups are too difficult for beginners, nothing is lost by the omission, and space is gained for more satisfactory treatment of the other groups.

For use within the range indicated, this is a most satisfactory spring flora and may be confidently recommended. W. L. E.

Biologisches Praktikum, für höhere schulen, von Professor Dr. Bastian Schmid. Mit 93 abbildungen im text, und 9 tafeln. Pages 78. 15x23 cm. 1914. M2. B. G. Teubner, Leipzig und Berlin.

This is a laboratory manual for high schools along the usual lines of the evolution series in the zoology section, but largely physiological on the plant side. The book does not contain anything of importance for American teachers, but the series of nine tables which it contains is valuable, for they are well done. The series is devoted to animals and includes dissections of the beetle, fish and three tables of dissections of the frog. Other tables are comparative studies of the heart, the brain, the stomach and the skeleton. Teachers who do this sort of work will find these drawings very useful. W. W.

Constructive Geometry, prepared under the direction of Earle R. Hedrick, University of Missouri. Pages vi+75. 20x26 cm. Paper covers. 1916. The Macmillan Company, New York.

In other countries, preparatory work for the course in geometry has received much attention and various kinds of textbooks have been published for the use of teachers in giving this work. It is well that the need of such work in our own schools is more fully realized, and that some teachers are interested enough to experiment and abolish the result of their labors for the use of others. This book furnishes a large number of exercises in measuring, drawing, and constructing geometrical figures, and problems to be solved by the use of compasses, ruler, and so on. Blank pages are inserted for the drawings, so that the work of the pupil may be preserved and improvement observed.

The fine heavy paper and excellent typography and illustrations will inspire the pupils to make clean and exact constructions. The selection and arrangement of the exercises and problems seem to be the result of much thought and experimentation. It is to be hoped that this book will interest teachers to secure the introduction of a course in constructive geometry into the curriculum of their school. H. E. C.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

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